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ABSTRACT

A research project, which involved a review of welding education research and surveys of welders in two states and the presidents of chapters of the American Welding Society throughout the United States, was conducted to gather empirical data from which welding curricula may be revised so as to reflect the changes in the welding industry caused by the recent upheaval in the U.S. economic system. It was concluded that high school students anticipating a career in welding should take basic education classes involving the scientific laws of mechanics, mathematics, human relations, communications, and economics related to employment and home. Vocational training schools teaching welding should broaden their curricula to encompass the training requirements for weld-fitters to provide for their acceptance within many industrial concerns. To bridge the gap between schools and industry, vocational schools should expand cooperative training programs and should develop a closer working relationship with their advisory committees. Because of the rapidity of economic change within our nation, vocational schools must conduct periodic surveys to determine the acceptability of their graduates within their respective geographic areas of concern. (Appendixes include comments made by respondents and copies of the two survey instruments.) (MN)

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WELDING EDUCATION RESEARCH (1964-1984)

Charles Frederick Bacon

A post masters degree study conducted for the purpose of updating welding technology curriculum at Everett Community College and for others with comparable needs.

This study is being conducted by the above-named person in cooperation with the welding faculty and administration at Everett Community College.

1984

WELDING EDUCATION REVIEW (1964-1984)

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WELDING EDUCATION RESEARCH (1964-1984)

Overview of Research

This study's development has included Chapters I, II, III, IV, V, VI and VII followed by a bibliography and appendices. Chapter II has presented a review of related research relevant to this study. Chapter III has presented a summary of the preliminary questionnaires. Chapter IV provides for an analysis of welding occupational survey data as reported by regional industrial respondents. Chapter V, like Chapter IV, provides an analysis of national survey data. Chapter VI provides for a comparative analysis of Bacon's 1964 Thesis "Development and Evaluation of a Resource Unit in Welding and Metallurgy for the Welding Technician Program" and his "1974 Welding Task Analysis" which were supervised by the late Dr. Athol R. Baily, University of Washington, with this current study data. Chapter VII provides a summary of the analytical study together with conclusions and recommendations. The final sections of the study have included the appendices and charts.

WELDING EDUCATION RESEARCH (1964-1984)

CHAPTER I

INTRODUCTION

This post master's degree research is being conducted for the purpose of providing current empirical data from which welding curriculums may be revised to reflect the changes caused by the upheaval in our economic system.

An analysis has been made to determine how these changes in American Industry affect the employer, the welder, the welding instructor and the welding industry.

A review of current welding education research has been sought through "Education Research Center" (ERIC), University of Washington.

This writer in his 1974 study sought to determine what type of occupational ladder was most commonly used within industry, if one actually existed. This welding study of 1984 was conducted to verify conclusions of the previous 1974 study.

Purpose of the Study

During the time period of the late 1970's and the early 1980's economic upheavals largely unseen since the beginning of the industrial revolution have occurred, directly or indirectly affecting every human being.

The increased inability of American Industry to compete in the world market has forced disastrous changes within the industrial community. We see automated factories utilizing many innovations requiring an entirely differently trained work force.

To meet this challenge the vocational education community needs to re-examine its precepts so students are not trained for nonexistent jobs.

Need for the Study

The following reasons demonstrate the need for this study:

1. There are many unemployed welders.
2. Enrollment of vocational welding students has fallen off sharply.
3. Does industry need welder-fitters in lieu of persons trained primarily as welders.
4. Have various aspects of automation changed the basic training requirements for welders and/or welder-fitters.

Methods of Research and Sources of Data

Methods of Research. To secure current information relative to the welder's training needs a descriptive survey was used. The survey in Washington and Oregon states consisted of a preliminary and a secondary in-depth questionnaire. Only the in-depth questionnaire was sent to regional presidents of the American Welding Society chapters throughout the United States. (See Appendix D, page 97.)

Sources of Data Data sources for this educational research included the following: production welders, welding supervisors, employers of welding personnel, regional presidents of the American Welding Society and professionally related literature from societies, government and educational agencies throughout the United States.

Five hundred and five (505) letters of inquiry were mailed to regional industrial concerns within the States of Washington and Oregon. From this group eighty (80) were returned with sixty-two (62) indicating a desire to cooperate further in the study. To provide greater validity, forty-seven other regional industrial concerns were added to the mailing list for a total of one hundred nine (109). An in-depth questionnaire was mailed to the one hundred nine (109) regional industries.

To provide a comparative basis for the regional data one hundred thirty-seven (137) questionnaires were sent to regional presidents of the American Welding Society throughout the nation. For additional data sources the writer has relied upon his welding related experiences, observations and the valuable expertise of others in the welding occupations.

A review of current welding education research was conducted through "Education Resource Center" (ERIC), University of Washington.

Limitations

This welding technology educational review is limited in the following ways:

1. The regional aspects of this study are limited to the geographical boundaries of Washington and Oregon.
2. The in-depth questionnaire was utilized in both the region and nation.
3. The preliminary questionnaire of eight (8) questions was limited to five hundred and five (505) industries within the region.

4. The secondary in-depth questionnaire was limited to one hundred and nine (109) metal working industries within Washington and Oregon.

5. To provide a comparative base for evaluation this same in-depth questionnaire was sent to one hundred thirty-seven (137) regional presidents of the American Welding Society throughout the United States who represent the various aspects of industry employing welders.

6. The data obtained from this survey was limited to the respondent's willingness to answer.

7. The study was limited to the metal working industries utilizing the welding processes in their fabrications.

8. The welding processes of concern have included: shielded metal arc welding (SMAW), gas tungsten arc welding (GTAW), gas metal arc welding (GMAW), flux cored arc welding (FCAW) and submerged arc welding (SAW).

9. This study has included limited research of current metal fabrication publications.

Definition of Terms

The following definition of terms is being provided to assure clarity of usage throughout the study.

Welding. The process by which two pieces of metal are united by heating them to a melting temperature and causing them to flow together.

Welder. An operator of welding equipment or an operator who makes welds (preferred definition). (This preferred definition shall be used throughout this study), also used to denote a welding machine.

Weld. A localized coalescence of metal wherein coalescence is produced by heating to suitable temperature with or without the application of pressure and with or without the use of filler metal. The filler metal either has a melting point approximately the same as the base metal but above 800°F.

Welding Operator. One who does welding. A welding operator is generally referred to as a welder. (Welder preferred)

A.W.S. American Welding Society, 2501 N.W., 7th Street, Miami, Florida 33125.

A.S.T.M. American Society of Testing Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

N.R. No response.

W.S. Welding Supervisor.

N.C.G. National Control Group.

E.R.I.C. Education Resource Center.

Descriptive-Survey. A descriptive survey is an inclusive term that includes the gathering of present facts and the study of current conditions to indicate the nature or status of the subject being studied.

CHAPTER II

REVIEW OF RELATED RESEARCH

A computer search of related research has been conducted by the University of Washington Libraries computer-based "ERIC" database reference services. The following areas of concern were searched:

1. Welders' skills and competencies;
2. Metal fabrication skills;
3. Welding instructors' qualifications - both academic and vocational skills.

The areas searched produced a printed packet of eighty (80) items with a broad range from the many related topic descriptors. Of the eighty items produced as a result of the search, very little was directly relevant to the objectives of this study.

CHAPTER III

SUMMARY OF PRELIMINARY QUESTIONNAIRE

The preliminary letter of inquiry which included eight (8) questions was mailed to five hundred and five (505) industrial concerns throughout Washington and Oregon states potentially employing welders. From the varying industrial concerns there were eighty (80) or 16% of the questionnaires returned with sixty-two (62) or 12% willing to cooperate further in an in-depth welding study.

Analysis of Preliminary Questionnaire

Question one of the preliminary questionnaire has sought to establish a list of the industries utilizing the welding processes who are willing to cooperate further in an in-depth study of welding which are provided in Appendix C, page 95.

Question two asked: "Does your industrial concern employ welders?" Appendix A, Part III, Table 1b, page 84 provides a statistical breakdown of the data provided by the respondents.

yes	61	(98.5%)
no	1	(1.5%)

Those industries desiring no further cooperation in the study stated they either hired only through the union halls or do not employ welders.

Question three asked: "Does your industrial concern employ welder-fitters?" Of the fifty-eight responses forty-eight (48) or (77%) of the respondents hire welder-fitters while ten (10) or (16%) do not employ them. (No response on four questionnaires.)

Question four: "What percentage of your welders are hired directly upon graduation from vocational welding schools?" Of the reporting industries thirty-eight (38) or 61% do not hire any welders directly from vocational training programs while sixteen (16) or 25% do hire directly. The other varying responses have been reported with the statistical data. Appendix A, Part III, Table 1b, page 84 provides a percentage breakdown of the statistical data for the reporting industries.

Question five: "Would you hire welder-fitters if they were available from local welding schools?" Of those responding, thirty-four (34) or 55% indicated yes while nineteen (19) or 31% indicated no. See Appendix A, Part III, Table 1b, page 85 for statistics.

Question six: Do you feel that entrance welders could be more adequately trained by the schools for your welding needs?" Those responding to this question indicated yes by forty-four (44) or 71% and no by ten (10) or 16% while seven (7) or 11% did not respond. See Appendix A, Part III, Table 1b, page 85 for the statistical data provided.

Question seven: "Would you consider the following occupational ladder relevant in your industrial concern in 1984? Please check those job categories relevant to your industry.

	Yes	No
(a) Helper	38 or (51%)	10 or (16%)
(b) Limited tacker	15 or (24%)	29 or (47%)
(c) Welder journeyman	59 or (95%)	1 or (2%)
(d) Welder (special or supervisor)	34 or (55%)	12 or (19%)
(e) Welder (engineer or instructor)	13 or (21%)	26 or (42%)

Large percentages of the industrial concerns do hire helpers, welder journeyman and welder (specialist or supervisor); whereas, the limited tacker was hired by only 24% and the welder (instructor or engineer) by 21%. The data provided by the industrial comments indicate that mainly only the larger high volume industries hire welding instructors and engineers. The industrial comments are provided in Appendix A, Parts I & II, pages 76-82.

CHAPTER IV

WELDING OCCUPATIONAL SURVEY DATA ANALYSIS AS REPORTED BY REGIONAL INDUSTRIAL CONCERNS

Analysis of Welding Questionnaires Sent to Regional Industrial Concerns

Questionnaires were mailed to sixty (60) regional industries desiring further cooperation in the study plus forty-nine (49) additional copies to industries either not responding to the original mailing or to industries added to the revised mailing list for a total of one hundred nine (109). From this mailing there were thirty-four (34) returned with thirty-three (33) or 30% usable and one (1) 1% not usable.

This questionnaire consisted of forty-five (45) questions divided into five subdivisions: general information, basic education requirements, welding related knowledge requirements, welder and/or fitter related skills and functions, manipulative skills for a production welder and/or fitter and future welding trends. The questions require single or multiple response to the statements by circling one of three choices (N) necessary, (D) desirable, or (U) unnecessary to indicate their importance to the respondent.

This survey instrument was designed to determine the greatest number of common needs presented by the various facets of industry relative to welding processes, materials, filler metals, weld positions most used and the basic and general welding knowledge required by industry.

The industries responding to this survey represent both small and large industrial concerns hiring from two to three hundred fifty (2-350) welders.

No attempt has been made to provide a comparative analysis between the various types of industry represented by this study. All types of the metal working industries have been represented within this study.

The analysis of the regional questionnaire has been presented question-by-question within each section accompanied by the necessary data tabulation and referenced.

GENERAL INFORMATION

In question one (1) the respondents' names have not been provided to protect their identity.

Question two: The industrial concerns represented by this study are provided in Appendix C, pages 95-96.

Question three represents the different types of products manufactured by the respondents represented in the regional aspects of this study. These are presented in Apendix E, pages 100-101.

Question four: "Welder entry level skill requirements:" The skill level required for entry level employment expressed in years as follows: (a) 1 year - 30%, (b) 2-5 years - 42%, and (c) for the journeyman - 39%, the others gave no response.

Question five: "Does your industry require certification testing?" Of the industries responding 76% require certification, while 30% do not. In part (a) of this question 33% require unlimited certification while 56% require only a limited certification. In part (b) Industry requires 15% of their employees to certify on the E60XX series electrodes while 42% utilize the E70XX series electrodes, another 15% certify on gas tungsten arc welding (GTAW) or gas metal arc welding (GMAW). Part (c) to this question requests the type of materials being welded and is shown in Table XI, page 104. Further data tabulation provided as follows:

(1) Plate:	51%	(2) Pipe:	42%	(3) Others:	
3/8 or less	36%	1" or less	21%	Sheetmetal	33%
3/8 to 1"	39%	1" to 6"	33%	Galvanized	15%
1" or above	39%	6" and above	33%	High alloy steel	30%
		.020 and above	3%	Stainless steel	45%
				Aluminum	30%

Comments are provided in Appendix B, Part 1 & 2, pages 76-82.

Question six: "Is your shop union affiliated?" To this question 59% indicated yes while 41% were not affiliated.

Question seven: The average monthly number of welders reportedly employed by the Regional industries was 1,118.

Question eight: "Is a physical examination required for your welding personnel?" There were 52% requiring a physical examination for employment while 48% had no requirements.

Question nine: "By which of the following methods are your welding personnel recruited?"

1.	Advertisement in local papers	56%
2.	Welding schools	36%
3.	State Employment Service	30%
4.	Union hall	24%
5.	Private Employment Service	15%
6.	Other methods	39%

Of the reporting industries the largest percentages of welders were recruited by advertisement in local papers, the welding schools and State Employment Services. The thirty-nine percent (39%) represented by other methods have included walk-in applicants, personal reference and plant employee referrals.

Question ten: "Do you have any general education grade level requirements?" There were 39% requiring a minimal education level while 58% do not. Of this group 30% require a high school education, and 24% require vocational-technical school training.

Question eleven: "Your welders were trained principally by:"

1.	Vocational schools	42%
2.	Community college	36%
3.	Union trade schools	33%
4.	High school vocational programs	12%
5.	Other	15%

The other methods of training included union or plant apprentice programs and in-house on-the-job training.

(b) "Was vocational training adequate for your entry level workers?" Of the industries reporting on this question 40% indicated yes while 46% reported no. One respondent to this question reported, sometimes. The comments for this question are listed in Appendix B, part III, page 87.

BASIC EDUCATION

The basic education section of this questionnaire encompassing questions twelve through sixteen are based upon thirty-three reporting industries which have been reported in tabulated form in Table II, page 106.

Question twelve: The welder-supervisory inter-personal skill development was deemed necessary by 30% and desirable by 42% of the respondents reporting. In part (b) of this question the welder-peer worker relationship was considered necessary by 24% and desirable by 64% of those reporting.

Question thirteen: The welders' basic understanding of the application of scientific laws as related to mechanics was felt necessary by 64% of the reporting industrial respondents.

Question fourteen: The mathematical problem solving ability of the welder was felt desirable by 49% of the respondents in arithmetic through basic algebra.

Question fifteen: In communications, writing reports was considered unnecessary by 52%, verbally directing others was considered necessary by 39% and desirable by 56%. The ability to receive verbal communication was considered necessary by 85% of the respondents. The use of planning or procedure specification sheets was considered necessary by 58% and desirable by 33% of the industrial respondents.

Question Sixteen: The following economic courses were considered as to their necessity for the welder in the following manner. Courses on employment were considered desirable by 42% and unnecessary by 56%. Income and taxes was felt to be unnecessary by 73% while the study of industrial organizations was considered desirable by 49% and unnecessary by 39% of the respondents. The study of family financial management was considered desirable by 39% and unncecessary by 56%. The tabulation of this data on communications has been presented in Table II, page 106.

WELDING RELATED KNOWLEDGE REQUIREMENTS

This section on welding related knowledge requirements encompasses questions seventeen (17) through thirty-five (35). The statistical data pertinent to this section has been provided in Table II, pages 106-108.

Question seventeen: The welders' ability to interpret blueprints, shop drawings and welding symbols was thought necessary by 79% of the respondents.

Question eighteen: The ability to make simple pictorial and three view drawings was felt necessary by 27% and desirable by 56% of the respondents.

Question nineteen: The ability to interpret and use drawings related to hydraulics and pneumatic systems was considered desirable by 42% and unncessary by 52% of the respondents.

Question twenty: The ability to interpret and use electrical drawings related to welding equipment was considered desirable by 36% and unnecessary by 61% of the respondents.

Question twenty-one: The welders' ability to fit up parts for welding was considered necessary by 79% of the respondents.

Question twenty-two: The knowledge of the welding characteristics sought by this question has subdivisions (a) through (f) for the following metals:

(a) Carbon steel was considered necessary by 70% and desirable by 30%;

(b) Alloy steel necessary by 52% and desirable by 46%;

(c) Stainless steel necessary by 61% and desirable by 39%;

(d) Aluminum alloys necessary and desirable by 42%; while

(e) Titanium was considered desirable by 39% and unnecessary by 42%.

In division (f) of this question the respondents felt the nickel and copper alloys were also important.

Questions twenty-three: This question on the heat-treatment of metals has four subdivisions. (a) Annealing 61% desirable, (b) Normalizing 61% desirable, (c) Hardening 52% desirable, while (d) on tempering was 58% desirable. Of the respondents answering this question approximately 30% conside[illegible] heat treating unnecessary for the welder.

Question twenty-four: The welders' understanding of electricity as related to:

(a) The AC-DC rectifier type welding power source was considered necessary by 30% and desirable by 58%,

(b) Motor-generator power source necessary 18% and desirable 64%, while

(c) Alternating current power source was considered desirable by 70% of the respondents.

Question twenty-five on the metallurgical properties of metals as related to weldability, melting point, tensile strength, brittleness, yield point, expansion and contraction was considered necessary by 18% and desirable by 73%.

In question twenty-six 85% of the respondents considered an understanding of the design for welded structures desirable for the welder.

In question twenty-seven the welders' understanding of the methods of distortion control was considered necessary or desirable by 50% of the respondents.

In question twenty-eight an understanding of the basic type joints and their characteristics when welded was considered necessary by 58% and desirable by 42% of the respondents.

Ouestion twenty-nine on the affect of welding upon heat-treated metal was considered necessary by 46% and desirable by 49% of the respondents.

Question thirty: The welders' understanding of welding terminology was considered necessary by 76% and desirable by 24% of the respondents.

Question thirty-one: The welders' understanding of inspection and quality assurance methods was considered necessary by 55% and desirable by 42% of the respondents.

Question thirty-two: The welders' understanding of inspection and testing processes was considered necessary by 33% and desirable by 61% of the respondents.

Question thirty-three: The reporting industries considered the welders' understanding of cost related factors desirable by 82% of the respondents.

Question thirty-four: The welders' understanding of cost estimating was considered desirable by 67% and unnecessary by 30% of reporting industries.

Question thirty-five: The three production related factors are reported as follows:

(a) Understanding the cutting of metals with respect to the various cutting processes and their limitations was considered necessary by 33% and desirable by 61% of the respondents.

(b) An understanding of the codes and specifications related to welding; such as, pressure vessels, piping, building safety, etc., was considered desirable by 52% of the respondents.

(c) An awareness of hazardous fumes and gases when welding on certain materials was considered necessary by 73% and desirable by 27% of the industrial respondents.

For complete tabulation of the previous questions see Table II, page 108.

WELDER AND/OR FITTER RELATED SKILLS AND FUNCTIONS

Question thirty-six with subdivisions (a) through (o) has been shown in Table II, page 108. This question concerns itself with welder and/or fitter related skills and functions. Those functions thought necessary by over 40% of the respondents included: grinders and sanders, efficient use of small hand tools, jigs and fixtures, hydraulic lifts or fork trucks, pneumatic tools, rigging hoist or jib boom and the bridge crane. Likewise, those functions considered unnecessary by 30% or more of the respondents included the following: the lathe, shaper, mill and other machining tools, press brake, punch, squaring shear and the nibbler.

Question thirty-seven on welding related functions has subdivisons (a) through (n) which are listed in Table II, pages 108-109. Those related functions considered necessary by over fifty percent of the respondents include oxyacetylene gouging, arc gouging, select electrodes for the job, position for job, perform layout operations, and fit up for the job. Those functions considered unnecessary by thirty-seven percent or more of the respondents included metal spraying and finishes, heat treating of metals, repair welding machines and program welding burning equipment. Several functions within the table having a desirable response of over forty percent may be either highly necessary or unnecessary.

MANIPULATIVE SKILLS FOR A PRODUCTION WELDER AND/OR FITTER

In question thirty-eight the welder and/or fitter were asked to list the weld positions most used for a specific type of weld joint and welding process. The shielded metal arc (SMAW) welding process was shown to have been the most used welding process for all the weld joint types. The second and third most used weld processes included gas metal arc (GMAW) and flux cored arc welding (FCAW) varying somewhat for the type of joint being welded. The gas tungsten arc (GTAW) welding process had the third greatest usage in all weld positions. For each weld joint, welding process and positions most used check Table II, pages 110-111 for the complete tabulation. Comments for this question are listed in appendix B, part V, 38a, page 89.

In question thirty-nine, "Do you restrict your welders to the use of deposition techniques:" such as, stringer beads, weave or the block weld. Seventy percent of those responding to this question restrict the weld technique only as required for the individual weld so specified by engineering. The comments provided by this question are listed in Appendix B, part VI, 39a, page 90.

Question forty: Does your company use special persons to write welding procedures? Ninety-one percent of the respondents hire special persons to write welding procedures. The greatest percentage are written by the welding supervisor followed by the welding engineer and/or an engineer. The consultant firm was the least used by the industrial respondents. Comments for question forty are found in Appendix B, Part VII, page 90.

FUTURE WELDING TRENDS

Questions forty-one through forty-five are related to what the respondents anticipate the future trends will be for welding.

Question forty-one: Do you expect the use of the following weld processes to increase, decrease or stay the same in the next decade? Those processes the respondents felt most likely to increase by 49% or more include gas metal arc (solid core) (GMAW), gas metal arc (dual shield) (FCAW) and plasma arc welding (PAW). The processes considered most likely to decline included oxyacetylene welding (OAW) and metallic arc welding (SMAW). The complete tabulation for questions forty-one through forty-five have been provided in Table II, pages 111-112.

Questions forty-two: Should welding schools be involved in teaching the following subject matter: welder certification, code requirements and fabrication methods. Of the responses given to this question over seventy-five percent considered this to be a function of the welding schools.

Question forty-three: Should welding schools enter into more cooperative educational programs with industry employing welders? To this question eighty-five percent of the respondents felt welding schools and industry should be cooperating to provide better trained entry level welders for industry. Comments from industry as to how this cooperative education approach might be instigated are provided in Appendix B, part VIII, pages 91-92.

Question forty-four: Do you have computerized cutting equipment. The responses to this question indicated thirty-three percent do have while sixty-four percent do not have computerized cutting equipment.

Question forty-five: Do you have any welding robots in your shop? There were ninety-four percent of the respondents who did not have any robotic welding equipment, but several industries indicated their intent to purchase very soon or in the year ahead. The comments to this question are provided in Appendix B, Part IX, page 93.

CHAPTER V

WELDING OCCUPATIONAL SURVEY DATA ANALYSIS AS REPORTED BY NATIONAL INDUSTRIAL CONCERNS

Analysis of Questionnaires Sent to Regional Presidents of the American Welding Society Throughout the Nation

Questionnaires were mailed to one hundred thirty-eight (138) regional presidents of the American Welding Society throughout the nation. Of this number there were thirty-eight or 28% returned which were usable. There were four or 3% non-usable.

This questionnaire was the same questionnaire which was mailed to industrial concerns throughout Washington and Oregon states consisting of five subdivisions: general information, basic education requirements, welding related knowledge requirements, welder and/or fitter related skills and functions, maniuplative skills for a production welder and/or fitter and future welding trends. The questions require either single or multiple response to the statement by circling one of the three choices (N) necessary, (D) desirable, or (U) unnecessary to indicate their importance to the respondent.

This questionnaire has sought to determine the industrial needs relative to welding processes, materials, filler metals, weld positions most used and the basic and general welding knowledge requirements for the entry level welder.

The industrial respondents cooperating in this study represent nearly every facet of the industrial community employing six thousand nine hundred and seventy-three (6,973) welders.

The data provided by this questionnaire representing various aspects of industry throughout the nation has been analyzed and presented within this study question by question accompanied by referenced tables and Appendices as required.

GENERAL INFORMATION

In question two the names of the industrial concerns have been provided in Appendix E, pages 100-101.

In question three the types of products manufactured by the responding industries are provided in Appendix F, pages 102-103.

The welder entry level requirements requested in question four are spread out with some industries having varying requirements. Forty-two percent of the respondents preferred one year while two to five years was favored by twenty-nine percent. Eight respondents (21%) required the journeyman level welder. See Table III, page 113 for the complete tabulation of data.

Question five: Does your industry require certification testing? Over seventy percent of the responses to this question require certification testing. For those firms requiring certification three subdivisions to this question seek additional information as follows. (a) If certification is required please identify: Of the responding industries 60% require an unlimited certification while 18% require a limited only. (b) Electrode types: Twenty-nine precent require use of the E60XX series electrode while sixty-one percent use the E70XX electrodes. Another 24% require the use of various other electrodes. (c) The part of the question on materials used was subdivided into plate, pipe and other metal categories. Plate is used by 61%, pipe by 66%, while the use of the other materials include sheetmetal 21%, high alloy steel 42%, stainless steel 58% and aluminum by 40%. For the complete tabulation of question five, please consult Table III, page 113.

Question six: Is your shop union affiliated? To this question 57% do have union affiliated shops while 40% do not and 3% gave no response.

Question seven: The average monthly number of welders employed throughout the United States by the respondents, represents both large and small industries employing from only one (1) to twenty-five hundred (2,500) welders for a total of 6,975.

Question eight: Is a physical examination required for your welding personnel? A physical examination was required by 71% of the responding industries while 29% do not require a physical examination for employment.

Question nine: By which of the following methods are your welding personnel recruited? The following methods for hiring welders have been listed starting with the greatest to the least:

(a)	Advertisements in local papers	19	or 50%
(b)	Welding schools	12	or 32%
(c)	State Employment Services	10	or 26%
(d)	Union halls	9	or 24%
(e)	Private employment services	3	or 8%
(f)	(Other) methods	13	or 34%

Of the (Other) methods - this group has included personal contact, referrals, walk-in applicants, high school and college programs and "in-house" bidding.

Question ten: Do you have any general education grade level requirements? If yes, please list.

Yes	18	or 47%
No	17	or 45%
N.R.	3	or 8%

The general education requirements most required for employment was high school 50% followed by the vocational technical school 13%. There were 45% of the responding industries having no general education requirements.

*Question eleven: Your welders were principally trained by:

(1)	Vocational schools	50%
(2)	Company training schools	42%
(3)	Vocational high school training programs	29%
(4)	Community college	18%
(5)	Union trade schools	11%

Another 13% were trained in one of the following three ways: On the job, other companies or by the "leader in welding".

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* Total percentage greater than 100% because some industrial concerns marked more than one training category for their workers.

BASIC EDUCATION

Question twelve: Inter-personal skills:

(a) The relationship between the welder-supervisory personnel was felt to be necessary by 18% and desirable by 61%, another 16% felt it was unnecessary; (b) The welders' relationship with his peer-workers was deemed necessary by 26% and desirable by 58% of the respondents.

Question thirteen: The basic understanding and application of scientific laws as related to mechanics: i.e., (levers) was felt desirable by 63% and unnecessary by 24% of the reporting industries.

Question fifteen: Communications:

(a) Writing reports was considered unnecessary by 63% of the respondents while 30% thought it desirable.

(b) To verbally direct others was considered desirable training by 66%.

(c) To receive verbal communications was considered necessary by 87% of the respondents.

(d) Using written planning or procedure specifications sheets was considered necessary by 68%.

Question sixteen: Economic courses as related to:

(a) Industry considered economic courses related to employment unnecessary by 55%.

(b) Courses in income and taxes unnecessary by 66%.

(c) Courses in industrial organization desirable by 50% and unnecessary by 47%.

(d) The courses in financial management were considered desirable by 32% and unnecessary by 61%.

WELDING RELATED KNOWLEDGE REQUIRMENTS

Question seventeen: Interpret blueprints, shop drawings and welding symbols. To this question the industrial respondents considered it necessary by 71% and desirable by 26%.

Question eighteen: Ability to make simple pictorial and three view drawings. There were 55% of the responding industries who considered this desirable with another 29% considering it unnecessary.

Question nineteen: The ability to interpret and use drawings related to hydraulic and pneumatic systems was felt unnecessary by 66% of the respondents.

Question twenty: The ability to interpret and use electrical drawings related to welding equipment was considered unnecessary by 64% of the respondents.

Question twenty-one: The ability to fit up parts for welding was considered necessary by 61% and desirable by 29% of the respondents.

Question twenty-two: Knowledge of the welding characteristics of:

(a) The welders need to know the welding characteristics of carbon steel was considered necessary by 68% and desirable by 21%.

(b) Alloy steels necessary by 58% and desirable by 29%.

(c) Stainless steel was considered necessary by 61% and desirable by 27%.

(d) The welding characteristics of aluminum was considered necessary 29%, desirable by 42% and unnecessary by 26% of the respondents.

(e) The welding of titanium was considered desirable by 50% and unnecessary by 42% of the reporting industries.

Question twenty-three: Heat treatment of metals: The heat treating of metals is subdivided into four separate units and has been individually evaluated as follows by the industrial concerns responding.

(a) Annealing desirable by 42% and necessary by 47%.

(b) Normalizing desirable by 40% and unnecessary by 53%.

(c) Hardening desirable by 40% and unnecessary by 53%, and

(d) Tempering desirable by 42% and unnecessary by 47%.

Question twenty-four: The understanding of electricity as related to welding has three subdivisions which have been evaluated separately as follows:

(a) AC-DC rectifier welding power source desirable by 66% and unnecessary by 21%.

(b) Motor-generator power source desirable by 58% and unnecessary by 37%.

(c) Alternating current power sources desirable by 58% and unnecessary by 32%.

Question twenty-five: Metallurgical properties of metals as related to weldability, melting point, tensile strength, brittleness, yield point, expansion and contraction. To this question the industrial respondents considered this knowledge desirable by 61% and unnecessary by 18%.

Question twenty-six: The welders' understanding of design for welded structure was considered desirable by 50% and unnecessary by 32% of the respondents.

Question twenty-seven: The welders understanding methods of distortion control was considered necessary by 42% and desirable by 50% of the respondents.

Question twenty-eight: The understanding of basic type joints and their characteristics when welded was considered necessary by 63% and desirable by 34% of the respondents.

Question twenty-nine: The affect of welding upon heat-treated metals was considered necessary by 32% and desirable by 45% of the responding industries.

Question thirty: The understanding of the terminology of welding was considered necessary by 61% and desirable by 29% of the respondents.

Question thirty-one: The welders' understanding of inspection and/or quality assurance was considered necessary by 42% and desirable by 50% of the respondents.

Question thirty-two: The understanding of testing and inspection processes was considered necessary by 21% and desirable by 61% of the respondents.

Question thirty-three: The welders' understanding of welding related cost factors was considered desirable by 63% but unnecessary by 32% of the industrial respondents reporting.

Question thirty-four: The welders' understanding of cost estimating was considered desirable by 53% and unnecessary by 45% of the reporting industrial respondents.

Question thirty-five: This production related question has three subdivisions:

(a) Understanding of the cutting of metals with respect to the various cutting processes and their limitations was considered necessary by 32% and desirable by 50%.

(b) Understanding of the codes and specifications related to welding; such as, pressure vessels, piping, building safety, etc., was considered desirable by 50% and unnecessary by 32% of the respondents.

(c) An awareness of hazardous fumes and gases when welding on certain materials was considered necessary by 63% and desirable by 34% of the respondents.

WELDER AND/OR FITTER RELATED SKILLS AND FUNCTIONS

Question thirty-six: Equipment operation has subdivisions (a) through (n) which have been evaluated and grouped as to their being necessary, desirable or unnecessary. The necessary evaluations of over 40% include grinders and sanders 71%, efficient use of small hand tools 74%, jigs and fixtures 45%, and pneumatic tools 42%. Those operations considered unnecessary for the welder evaluated by over 40% include the press brake 55%, punch 58%, squaring shear 50%, nibblers 50%, (lathe, shaper, mill and other machining tools) 71%, hydraulic lifts or fork trucks 42%, taps, dies and reamers 42% and the bridge crane 45%. For the complete tabulation of the data, please see Table III, pages 117-118.

Question thirty-seven: The questions on welding related functions have subdivisions (a) through (n) which have been evaluated and reported for those considered necessary and/or unnecessary. For the complete tabulation of this data consult Table III, page 118. The tabulations considered necessary by 40% or more included arc gouging, postion for job, perform layout operations, and fit up for the job. Those areas the respondents considered unnecessary by over 40% included metal spraying and finishes, perform hardfacing, heat treating of metals, machine cutting, repair welding machines, repair welding machine leads and grounds, and programmable welding burning equipment.

MANIPULATIVE SKILLS FOR A PRODUCTION WELDER AND/OR FITTER

Question thirty-eight: This question has sought to determine the weld joints, weld position and weld processes most used by the welder and/or fitter. For the butt joint shielded metal arc (SMAW) was most used followed by gas metal arc (GMAW). The third most used process was gas tungsten arc (GTAW). The lap joint was most used by the shielded metal arc (SMAW) process with gas tungsten arc (GTAW) next most used process. Gas metal arc (GMAW) was the third most used process. For the fillet joint shielded metal arc (GMAW) for all positions and gas tungsten arc (GTAW) was the third most used welding process. For the corner joint gas tungsten arc (GTAW) was the most used welding process with shielded metal arc (SMAW) and gas metal arc (GMAW) following in the order of usage. The usage of the edge joint in their order from most used to least included gas tungsten arc (GTAW), shielded metal arc (SMAW), and gas metal arc (GMAW); the flux cored arc welding (FCAW) and sub-merged arc weld (SAW) were the least used weld processes. The detailed account for this question has been provided in Table III, page 119.

Question thirty-nine: Do you restrict your welders to the use of deposition techniques; such as, the stringer beads, weave or the block weld? Over sixty percent of the responding industries only restrict the weld technique as required when specified by the welding engineer.

Question forty: Does your company use special persons to write welding procedures? Special persons to write welding procedures were employed by 89% of the reporting industries. The types of personnel so employed have been reported from the most used to the least used as follows: welding engineer 68%, technician 32%, engineer 21%, welding supervisor 11%, consultant firm 8%, with the welding Q.C. supervisor least used with 5%. Some industries use more than one special person to write weld procedures.

FUTURE WELDING TRENDS

Question forty-one: Do you expect the use of the following weld processes to increase, decrease or stay the same in the next decade? Those processes the respondents felt would increase by over forty percent included gas metal arc (GMAW) 58%, flux cored arc (FCAW) 63%, flux cored arc (FCAW) (self shielded) 53%, gas tungsten arc (GTAW) 53%, sub-merged arc (SAW) 47%, and plasma arc (PAW) 74%. The processes considered most likely to decrease by over forty percent included oxyacetylene (OAW) 53%, shielded metal arc (SMAW) 47%, and oxy-fuel gas 45%. For further observation the data is provided in Table III, page 120.

Question forty-two: Should welding schools be involved in teaching welder certification, teaching of code requirements and fabrication methods? To this question over 82% of the respondents considered it necessary. See Table III, page 121 for further details.

Question forty-three: Should welding schools enter into more cooperative education programs with industry employing welders? Seventy-nine percent (79%) of those responding to this question considered it necessary and their recommendations are provided in Appendix B, part VIII, pages 91-92.

Question forty-four: Do you have computerized cutting equipment? The responses to this question indicated 34% do have this type of equipment and 63% were desirous of obtaining computerized cutting equipment.

Question forty-five: Do you have any welding robots in your shop? Those responding to this question reported 10% do have them while 87% indicated it would be desirable. Appendix B, part IX, page 93 provides a listing of the comments to this question. The general comments from the questionnaires are provided in Appendix B, part X, page 94.

CHAPTER VI

A COMPARATIVE ANALYSIS OF THE WELDING EDUCATION STUDIES OF 1964, 1974 and 1984 WHERE APPLICABLE

A comparative analysis of Bacon's 1964 thesis "Development and Evaluation of a Resource Unit in Welding and Metallurgy for the Welding Technician Program," and the "1974 Welding Task Analysis" which were supervised by the late Dr. Athol R. Baily, University of Washington, have been compared section by section with current data which should denote the changing trends during the past twenty years. It is this writer's desire that through this study it may provide some direction for welding education.

The writer has used a similar format for each of these studies but a different emphasis prevails. The analysis in this chapter has dealt mainly with factors relative to the educational needs and requirements of the welder in the industrial setting.

In the comparison of data between the three studies there are many variables which produce approximate answers.

General Information

The industrial welding experience requirements during the past decade have increased. Approximately 70% of today's industry require welder certification; whereas, in 1974 there were 54% with a certification requirement. The type of certification sought in the 1984 study has shown that 52% require a limited certification with 42% using the E70XX series electrodes.

The 1974 data has shown that 44% of the industries reported upon by the welding supervisors required some type of certification; such as, Navy, Coast Guard, AWS, ASME or Seattle certification.

There were 1,293 welders represented for the 1964 study, 6,684 for 1974 and 8,091 for the 1984 study. Nearly every facet of industry employing welders has been represented.

Union affiliation was shown to be required by 69% of the welders in 1974; whereas, 59% were required in the 1984 study showing a slight decline.

The following occupational ladder was constructed from the data supplied by the 1974 study. This same occupational ladder was presented to industry to determine its acceptability in 1984. The percentages shown in the following chart were provided by regional industrial respondents on the preliminary questionnaire by those responding in 1984.

	Yes	No
(a) Helper	61%	16%
(b) Limited tacker	24%	47%
(c) Welder journeyman	95%	2%
(d) Welder (special or supervisor)	55%	19%
(e) Welder (instructor or engineer)	21%	42%

The limited tacker and the welder (instructor or engineer) have been the least used in the occupational ladder of 1984.

The physical examinations requirements were 46% by the welding supervisors in 1964 and 71% in the 1984 study.

The largest percentage of welders recruited in 1974 was through the union halls; whereas, in 1984 it was through advertisements in the local papers.

The general education grade level requirements for the entrance welder in 1964 was vocational training by 62% and in 1974, 58% of the welders had high school diplomas, with 38% of them having taken their welding training in vocational schools. In 1984 there were 50% of the industries requiring a high school diploma and the largest percentage of their welders were also trained in the vocational welding schools.

The adequacy of the welders training was reported to be acceptable by 60% in 1974, and 40% of both the regional and national respondents in 1984.

Basic Education: The importance of the welders interpersonal skills with his supervisors and his peer workers was considered desirable by over 42% of both regional and national respondents in 1974 and 1984.

The basic understanding of scientific laws as related to mechanics; i.e. (levers) was considered desirable by 53% in 1974 and by 64% in 1984.

The mathematical problem solving ability up through basic algebra was considered desirable by over 42% in 1964, 51% of the supervisors in 1974 and by over 49% in 1984.

The welders' ability to communicate by writing reports was considered necessary by 42% in 1964, 39% in 1974 and unnecessary by 52% of the regional and 63% national respondents in 1984. To verbally direct others was considered desirable by 54% in 1974 and necessary by 87% in 1984. To receive verbal communication was considered necessary by 83% in 1964 and 87% in 1984. The ability to write reports was considered unnecessary by 41% in 1974 and 52% in 1984.

Economics as related to employment, income and taxes, industrial organizations and family finance management has been considered and reported as follows. They were considered unnecessary by over 41% of the respondents in 1974 and 47% in 1984.

In 1964 the study of psychology and political science was considered unnecessary for the welder by over 78%.

Welding Related Knowledge Requirements. The welders' ability to interpret blueprints, shop drawings and welding symbols was considered necessary by over 47% in 1964, 60% in 1974 and 71% in 1984. The welders' ability to make simple pictorial and three view drawings was considered desirable by 50% in 1964, 66% in 1974 and by 55% in 1984. The ability to use drawings related to hydraulics and electrical was considered unnecessary by 66% or more in 1964 and 55% or more in 1984.

The welders' knowledge of the welding characteristics of the following metals was considered necessary as follows:

	1964	1974	1984
(a) Carbon steel	40%	78%	68%
(b) Alloy steels	40%	61%	58%
(c) Stainless steels	40%	51%	60%
(d) Aluminum alloys	--	42%	29%
(e) Titanium alloys	--	24%	0%

From this statistical data it provides the reader with a comparative basis for evaluation.

The heat treating of metals as related to annealing, normalizing, hardening and tempering or drawing was considered unnecessary by 37% to 42% in 1964, 35% to 52% in 1974 and from 47% to 53% in 1984.

The welders' understanding of electricity as related to the AC-DC rectifier, motor generator and the alternating current power sources was considered desirable by 47% in 1964, over 51% in 1974 and by 58% or more in 1984.

The metallurgical characteristics of metals as related to weldability, melting point, tensile strength, brittleness, yield point, expansion and contraction was considered necessary by 29% in 1964, 42% in 1974 and 16% in 1984, but considered desirable by 61% in 1984.

The welders' understanding of design for welded structures was considered desirable knowledge by 57% in 1964, 44% in 1974 and 50% of the respondents in 1984.

The understanding of the basic type of joints and their characteristics when welded was considered necessary by 65% in 1964, 63% in 1974 and 63% in 1984.

Understanding of the affect of welding upon heat treated metal was considered necessary by 53% in 1964, 47% in 1974 and 32% in 1984.

Understanding of welding terminology was considered necessary by 73% in 1964, 78% in 1974 and 60% in 1984.

An understanding of the process of testing and inspection was considered necessary by 33% in 1964, 39% in 1974 and 21% in 1984.

An understanding of the welding related cost factors was considered desirable by 56% in 1974 and 63% in 1984.

The welders' understanding of estimating costs for bidding was considered desirable by 51% in 1964 and by 52% in 1984.

The understanding of welding sequences as related to distortion control was considered necessary by 61% in 1974 and by 42% in 1984.

The understanding of the basic type joints and their characteristics when welded was considered necessary by 65% in 1964, 63% in 1974 and 63% in 1984.

The understanding of cost related factors related to the cutting of metals with respect to the various cutting processes and their limitations was considered desirable by 51% in 1974 and 47% in 1984.

An understanding of the welding codes as related to welding; such as, pressure vessels, piping, safety, etc., was considered desirable by 39% of the respondents in 1974 and 47% in 1984.

An awareness of hazardous fumes when welding on certain metals was considered necessary by 75% in 1974 and 63% in 1984.

Welder and/or Fitter Related Skills and Functions. Welders related skills and functions relative to the following equipment have been presented in the following chart:

Equipment operation:	1974 N	1974 D	1974 U	1984 N	1984 D	1984 U
(a) Press brake	17%	31%	52%	8%	34%	55%
(b) Punch	11%	37%	52%	13%	26%	58%
(c) Band saw	26%	34%	40%	26%	39%	32%
(d) Grinders and sanders	63%	20%	17%	71%	18%	8%
(e) Squaring shears	23%	29%	48%	18%	32%	50%
(f) Nibbler	--	--	--	10%	37%	50%
(g) Efficient use of small hand tools	60%	23%	17%	74%	21%	3%
(h) Lathe, shaper, mill and other machining tools	3%	14%	83%	5%	18%	71%
(i) Jigs and fixtures	49%	31%	20%	45%	47%	8%
(j) Hydraulic lifts and fork trucks	17%	26%	57%	18%	40%	42%
(k) Pneumatic tools	11%	32%	57%	42%	37%	18%
(l) Taps, dies and reamers	43%	17%	40%	18%	40%	42%
(m) Rigging hoist or jib boom	--	--	--	39%	24%	34%
(n) Bridge crane	--	--	--	32%	16%	45%

From the above chart the majority of related skills and functions are relatively similar except for taps, dies and reamers and pneumatic tools.

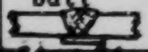
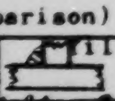
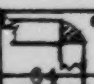
The welding related functions have been provided in the following table.

	1964			1974			1984		
Welding related functions	N	D	U	N	D	U	N	D	U
(a) Oxyacetylene gouging	--	--	--	37%	31%	32%	37%	24%	5%
(b) Arc gouging	--	--	--	66%	23%	11%	60%	24%	3%
(c) Metal spraying and finishes	--	--	--	2%	29%	69%	5%	21%	66%
(d) Perform hardfacing	--	--	--	34%	34%	32%	21%	31%	45%
(e) Heat treating of metals	--	--	--	17%	40%	43%	8%	37%	55%
(f) Select material for job	--	--	--	49%	37%	14%	21%	24%	55%
(g) Select electrode for job	76%	24%	0%	71%	20%	9%	39%	37%	21%
(h) Position for job	--	--	--	74%	23%	3%	50%	34%	16%
(i) Perform layout operations	--	--	--	--	--	--	50%	34%	16%
(j) Fit up for job	--	--	--	66%	23%	11%	55%	37%	3%
(k) Machine cutting	--	--	--	37%	40%	23%	24%	34%	42%
(l) Repair welding machines	76%	26%	0%	6%	49%	45%	0%	21%	71%
(m) Repair weld machine leads and grounds	--	--	--	34%	46%	20%	31%	24%	45%
(n) Programmable welding burning equipment	--	--	--	--	--	--	25%	37%	58%

In comparison with the 1974 study the ability to select electrodes, position for job and select materials for job has decreased in importance by over 25%

The weld joints, weld positions and the weld processes most used by the welder and/or fitters have been presented in the following chart with available data from the 1964 and 1984 weld studies.

(Regional data comparison)

Joint type	butt 						lap						fillet 						corner 						edge					
	64			84			64			84			64			84			64			84			64			84		
Weld processes	Arc	Tig	Mig	Arc	Tig	Mig	Arc	Tig	Mig	Arc	Tig	Mig	Arc	Tig	Mig	Arc	Tig	Mig	Arc	Tig	Mig	Arc	Tig	Mig	Arc	Tig	Mig	Arc	Tig	Mig
Flat weld	97%	72%	80%	70%	46%	60%	94%	61%	77%	61%	33%	46%	87%	61%	80%	67%	38%	53%	87%	65%	74%	64%	39%	47%	71%	52%	61%	58%	36%	41%
Horizontal weld	97%	58%	65%	67%	46%	46%	81%	54%	71%	64%	33%	43%	90%	61%	77%	67%	36%	36%	90%	65%	71%	64%	42%	42%	74%	58%	55%	55%	30%	30%
Vertical weld	97%	55%	55%	61%	36%	39%	84%	58%	55%	49%	30%	24%	90%	58%	58%	68%	36%	37%	87%	55%	52%	54%	36%	33%	84%	52%	48%	51%	30%	18%
Overhead weld	80%	48%	42%	51%	18%	21%	81%	53%	45%	45%	18%	18%	90%	73%	48%	52%	34%	18%	77%	43%	38%	42%	15%	24%	81%	48%	36%	42%	21%	15%

(Mig - solid wire)

The weld processes, shielded metal arc welding (SMAW), gas tungsten-arc welding (GTAS), and gas metal arc welding (GMAW) have been shown to provide the reader with emperical data for comparison.

The future welding trends of the major welding processes in 1974 and 1984 have been based upon regional data only.

Weld Processes	1974	1984	1974	1984	1974	1984
	Increase		Decrease		Same	
Oxyacetylene	0%	5%	59%	53%	20%	29%
Metallic arc	61%	18%	20%	47%	10%	24%
Gas metal arc welding (solid core)	81%	58%	5%	16%	7%	21%
Flux cored arc welding (inner shield)	85%	53%	0%	11%	5%	24%
Gas tungsten arc welding	90%	53%	7%	5%	5%	29%
Plasma arc	81%	74%	5%	0%	15%	21%
Ultrasonic	76%	21%	0%	5.3%	17%	34%
Submerged arc	0%	47%	0%	5%	5%	32%

Of the weld processes oxyacetylene welding usage remains on the decrease. Metallic arc welding was considered to be on the increase in 1974, whereas it was considered to decrease in 1984. The increased use of ultrasonic welding anticipated in 1974 had not materialized in 1984. The Appendix lists many remarks relative to chapter VI with tables and other supporting data.

CHAPTER VII
SUMMARY OF THE ANALYTICAL STUDY TOGETHER WITH CONCLUSIONS AND RECOMMENDATIONS

Preliminary Questionnaire Summary

The information needed for this study has been provided by a two stage industrial survey. The preliminary questionnaire consisted of an introductory letter with an eight question survey which was mailed to five hundred five (505) Washington and Oregon state metal working industries seeking their cooperation in an in-depth study. The eight questions of this survey questionnaire included (1) Name or address correction if required (2) Do you employ welders? (3) Do you employ welder and/or fitters? (4) Percent of welders hired directly from vocational welding schools (5) Would you hire welder-fitters if they were available from your local welding schools? (6) Do you feel entrance welders could be more adequately trained for your welding needs? (7) Would you consider the occupational ladder presented relevant in your industrial concern and (8) Would you assist by having a typical welder or welding supervisor fill out an in-depth questionnaire.

From this initial regional survey there were eighty (80) or 16% of the questionnaires returned of which sixty-two (62) or 12% were usable. Of the sixty-two (62) there were fifty-two (84%) who were willing to cooperate further in this in-depth study. For detailed analysis of this questionnaire data please see Appendix A, part 1B on pages 84-85. Industrial comments are provided in Appendix A, part 1, pages 76-80 and Table I, pages 83-84.

From the eighty (80) responding industries of the preliminary questionnaire sixty-two (62) were considered usable for data computation. Another eighteen (18) were not considered usable. Of the questionnaires considered usable, only fifty-two (52) desired further cooperation in the study. Of those responding in question two, sixty-one (61) or 91.5% hire welders. The industries desiring no further cooperation in the study stated they did not hire welders or only hired through the union hall. In question three there were forty-eight (48) or 77% of the respondents who employ welder-fitters. In question four there were sixteen (16) or 26% of the reporting industries hiring entrance level welding students directly from vocational schools while thirty-six (36) or 58% hire none. Of those responding to question five, thirty-four (34) or 55% would hire welder-fitters directly from local welding schools. There were forty-four (44) or 71% of the respondents who felt that entrance welders could have been more adequately trained by the schools for their welding needs.

In question seven: Would you consider the occupational ladder relevant in your industry in 1984? The occupational ladder presented was based upon data supplied by Bacon's study "1974 Welding Task Analysis:"

(a) helper	61%
(b) limited tacker	24%
(c) welder (journeyman)	95%
(d) welder (special or instructor)	55%
(e) welder (instructor or engineer)	21%

Question eight: Would you be willing to allow a typical welder or welding supervisor to fill out an in-depth questionnaire that would enable our welding schools to update their welding curriculums. Of the responding industries hiring welders there were fifty-two (52) or 86% that acknowledged their willingness to cooperate further in an in-depth study.

The second stage of the questionnaire was mailed to fifty-two (52) regional industries desiring further cooperation in the study plus fifty-seven (57) additional copies to industries either not responding to the original mailing or to industries added to a revised mailing list for a total of one hundred nine (109).

To provide a comparative data base for evaluation this same questionnaire was mailed to all one hundred thirty-eight (138) regional presidents of the American Welding Society throughout the United States.

From the 247 questionnaires mailed to regional and national industries there were seventy-one (71) returned usable questionnaires: thirty-three (33) regional and thirty-eight (38) national representing the various aspects of industry employing welders throughout the region and the nation.

The second stage of the survey consisted of a detailed questionnaire encompassing forty-five (45) questions divided into six sections:

(1) General education

(2) Basic education requirements

(3) Welding related knowledge requirements

(4) Welding and/or fitter related skills and functions

(5) Manipulative skills for a production welder and/or fitter

(6) Future welding trends

The data provided by the regional and national welding industrial respondents has been compared throughout this chapter section by section. Each section has been analyzed question by question and reported for their variations. These comparisons have been based upon all types of large and small industrial concerns.

GENERAL INFORMATION

The general information section for the needs and requirements has been reported in Table 1, pages 83-84, Tables II and III, pages 104 to 121.

In question one the names of the respondents have been omitted to protect their identity.

The industrial concerns in question two have been provided in Appendix C, pages 95-96 and D, pages 97-99.

In question three the products manufactured are listed in Appendix E and F, pages 100-103.

In question four, the entry level skill requirements have three subdivisions: (one year) 32% regional, 42% national, (two to five years) 42% regional and 29% national, (journeyman) 39% regional and 21% national.

In question five welder certification was required by 76% regional and 71% of the national respondents. In part (a) of this question 33% of the regional and 60% of the national industries require an unlimited certification. The limited certification was required by 52% of the regional and 16% of the national respondents. Part (b) of this question has shown 15% of the regional and 29% of the national require certification using E60XX series electrodes. The E70XX series electrode was required by 42% of the regional and 61% of the national respondents.

Part (c) of question five sought data on the types of materials most commonly welded. Plate welding was utilized by 51% of the regional and 61% of the national industries. Pipe welding was shown to be utilized by 42% of the regional and 66% of national industries. High alloy steels, stainless steel and aluminum were each shown to have considerable usage in both regional and national industries. The complete data computations for question five are listed in Table II and III, pages 104, 113, respectively. Comments for question five are provided in Appendix B, Part I on page 86.

Union affiliated requirements requested in question six were shown to be required by 59% of the regional and 58% of the national industries reporting.

There were 8,091 welders employed by the reporting industries in this study. Of this number 1,118 were from industries within Washington and Oregon states and 6,973 were from industries across the nation representing manufacturers hiring anywhere from (2 to 350) in the region and (1 to 2,500) in the nation.

A physical examination prior to employment was shown to be required by 52% of the regional and 71% of the national respondents.

In question nine information was sought to determine the most usual method welders are recruited for employment. The most usual methods have been listed from the greatest to the least used as follows:

		(Region)	(Nation)
(1)	Advertisement in local papers	55%	50%
(2)	Welding schools	36%	32%
(3)	State employment services	30%	26%
(4)	Union halls	24%	24%

Other miscellaneous recruiting methods were used to employ welders within the region and the nation.

Comments concerning question nine are provided in Appendix B, part II, page 87.

Question ten has sought to determine whether industry has general education requirements and if so, what are they. Thirty-nine percent (39%) of the regional and 47% of the national respondents require some form of basic education. There were 30% of the region and 50% of the national requiring high school while vocational technical school training was required by 24% regional and 13% national respectively.

Question eleven has sought to determine where the entrance welders were trained for industry. The responses to this question have been listed in their order of importance:

A. Types of Schools	Regional	National
(1) Vocational schools	42%	50%
(2) Company training schools	15%	42%
(3) High school vocational programs	12%	29%
(4) Community college	36%	18%
(5) Union trade schools	33%	11%

B. Was vocational training adequate for your entry level workers?

Regional	National
39.5% yes	39.5% yes
45.5% no	37% no

The method of training seems to vary between the regional and national data but the adequacy of the training has remained approximately the same. Comments for question eleven are provided in Appendix B, part III, page 87.

BASIC EDUCATION

The section on basic education encompassing questions twelve through sixteen has been based upon 33 regional and 38 national questionnaires.

The complete data tabulation is provided in Table II and III, page 106, 115, respectively.

Question twelve concerns itself with the inter-personal skills required for a welder and their importance to the welding industry. The welder-supervisory personnel relationship was considered necessary by 30% regional and 18% national and desirable by 42% and 61% respectively. The welder-peer worker relationship was considered necessary by 24% regional, 26% national and desirable by 63% and 58% respectively.

The understanding of the scientific laws pertinent to welding and mechanics has been considered relative to the training of welders. The industrial responses indicated their necessity by a 18% regional and 8% national response and desirable by 64% of the regional and 63% of the national respondents.

In question fourteen the welders mathematical problem solving ability was considered necessary by 21% of the regional and national respondents and desirable by 49% of the regional and 50% of the national respondents.

In the area of communications the respondents considered it necessary to verbally direct others by 39% regional, 18% national; receive verbal communications by 85% regional and 87% national; to use written reports 58% regional and 68% national while the ability to write reports was considered unnecessary by 52% regional and 63% of the national industrial respondents.

In question sixteen the curriculum aspects of economics as related to the welder has four divisions. Part (a) responses on employment were listed as 42% desirable for the region and 32% for the nation. It was considered unnecessary training by 55% of the regional and national respondents. (b) The training on income and taxes was considered unnecessary by 73% for the region and 66% throughout the nation. (c) The training related to industrial organizations was considered desirable by 49% for the region and 50% for the nation and unnecessary by 39%, and 47% respectively. (d) The responses to family finance management training was considered unnecessry by 56% for the region and 61% nationally.

WELDING RELATED KNOWLEDGE REQUIREMENTS

Questions seventeen through thirty-five have sought information on welding related knowledge requirements and has been reported question by question. The tabulated data relevant to these questions has been provided in Table II and III, pages 106-108 and 116-117, respectively.

In question seventeen the welders ability to interpret blueprints, shop drawings and welding symbols was considered necessary by 79% of the region and 71% of the national responses.

The ability to make simple pictorial drawings and three view drawings requested in question eighteen were considered desirable by 55% of both the regional and national respondents.

In question nineteen the ability to interpret and use drawings related to hydraulics and pneumatics was considered unnecessary by 52% of the regional and 66% of the national respondents.

The ability to interpret and use electrical drawings related to welding equipment was considered unnecessary training by 61% of the regional and 64% of the national responding industries.

The ability to fit up parts for welding in question twenty-one was considered necessary by 79% of the regional and 61% of the national respondents.

The knowledge of weld characteristics sought by question twenty-two has subdivisions (a) through (e). Division (a) on carbon steel was considered necessary by 70% for the region and 68% nationally, (b) alloy steels, 52% regional, 58% national, (c) stainless steel 61% for the region and the nation, (d) aluminum was considered necessary by 42% for the region and 29% nationally. Part (e) on titanium alloys was considered unnecessary by 42% by the regional and national respondents.

Question twenty-three on the heat treatment of metals has subdivisions (a) through (d). Division (a) on annealing was considered desirable by 61% for the region and 42% nationally, but considered unnecessary by 30% of the regional and 47% of the national respondents. In part (b) normalizing was considered desirable by 61% of the regional and unnecessary by 53% of the national respondents, (c) Hardening of metals was considered desirable by 52% of the regional and unnecessary by 53% of the national respondents. (d) The tempering of metals was considered desirable by 58% of the regional and 42% nationally, but considered unnecessary by 47% of national respondents.

Question twenty-four on the welders' understanding of electricity as related to welding has subdivisions (a) through (c). Division (a) AC-DC rectifier welding power sources was considered desirable knowledge by 58% of the regional, 66% of the national respondents. (b) The motor generator power sources was considered desirable by 64% for the region and 58% nationally and (c) alternating current power sources was considered desirable by a 70% regional and 58% national respondents.

Question twenty-five on the metallurgical properties of metals as related to weldability, melting point, tensile strength, brittleness, yield point, expansion and contraction were considered desirable knowledge for welders by 73% of the regional and 61% of the national respondents.

The understanding of design for welded structures for question twenty-six was considered desirable knowledge for 85% of the regional and 50% of the national respondents.

In question twenty-seven the understanding of methods for distortion control were considered necessary knowledge by 49% of the regional and 42% of the national respondents.

The welders' understanding of basic type joints and their characteristics when welded in question twenty-eight was considered necessary by 58% of the regional and 63% of the national respondents.

Question twenty-nine on the affect of welding upon heat-treated metals was considered necessary by 46% of the regional and 32% of the national and desirable by 49% and 45% respectively.

The understanding of welding terminology in question thirty was considered necessary by 76% of the regional and 61% of the national respondents.

In question thirty-one the understanding of inspection methods and quality assurance was considered necessary and desirable by over 42% of both regional and national respondents.

The welders' understanding of testing and inspection processes was considered desirable by 61% of both the regional and national reporting industries.

The understanding of welding related cost factors in question thirty-three was considered desirable by 82% of the regional and 63% of the national respondents.

The understanding of cost estimating was considered desirable by 67% of the regional and 53% of the national but unnecessary by 30% regional and 45% of the national respondents.

Question thirty-five on production related factors has three subdivisions: (a) Understanding of the cutting of metals with respect to various cutting processes and their limitations. To this question there was over a 32% necessary and 50% desirable response by both regional and national respondents. (b) The understanding of codes and specifications related to welding; such as, pressure vessels, piping, building safety, etc., was considered necessary by over 18% and desirable by over 47% for both regional and national respondents. Part (c) to this question on awareness to hazardous fumes and gases when welding on certain materials was considered necessary by 73% regional and 63% of the national respondents.

WELDER AND/OR FITTER RELATED SKILLS AND FUNCTIONS

Question thirty-six on equipment operation has subdivisions (a) through (n) and has been reported in groups. Those operations with over 39% necessary response by regional and national respondents include the grinders and sanders, efficient use of small hand tools, jigs-fixtures, pneumatic tools, taps, dies and rigging hoist or jib boom. The skills and functions considered unnecessary by 39% or more by both regional and national respondents included the press brake, nibbler, rigging hoist or jib boom; lathe, shaper, mill and other machining tools. Hydraulic lifts and fork trucks were considered necessary by 46% of the regional respondents while 42% of the national respondents considered it unnecessary.

The functions considered unnecessary by over 42% of the national respondents included the punch, squaring shear, hydraulic lifts or fork truck; taps dies and reamers and the bridge crane. The following table provides a visual comparison item by item for each subdivision of question thirty-six.

(Question thirty-six)

Equipment operation:	(N%) Reg.	(N%) Nat.	(D%) Reg.	(D%) Nat.	(U%) Reg.	(U%) Nat.	(N.R.) Reg.	(N.R.) Nat.
a. Press brake	12	8	49	34	39	55	0	3
b. Punch	12	13	58	26	30	58	0	3
c. Bandsaw	33	26	46	39	18	32	0	3
d. Grinders and sanders	76	71	24	18	0	8	0	3
e. Squaring shears	15	18	49	32	36	50	0	0
f. Nibbler	12	10	49	37	39	50	0	3
g. Efficient use of small hand tools	73	74	24	21	3	2.5	0	2.5
h. Lathe, shaper, mill, and other machining tools	3	5	21	18	73	71	3	5
i. Jigs-fixtures	55	45	39	37	3	8	3	0
j. Hydraulic lift or fork lift	46	18	33	40	21	42	0	0
k. Pneumatic tools	52	42	30	37	18	18	0	3
l. Tools,dies & reamers	39	13	33	40	27	42	0	5
m. Rigging hoist or jib boom	52	39	33	24	15	34	0	3
n. Bridge crane	54	32	33	16	12	45	0	7

Question thirty-seven on welding related functions has subdivisions (a) through (n) and has been reported in the following comparative table and the following paragraphs:

37. Welding related functions:

	(N%)		(D%)		(U%)		(N.R.)	
	Reg.	Nat.	Reg.	Nat.	Reg.	Nat.	Reg.	Nat.
(a) Oxyacetylene gouging	61	37	24	24	15	34	0	5
(b) Arc gouging	70	60	30	24	0	13	0	3
(c) Metal spraying and finishes	6	5	33	21	61	66	0	8
(d) Perform hardfacing	21	21	49	31	30	45	0	3
(e) Heat treating of metals	3	8	58	37	37	55	0	0
(f) Select materials for job	30	21	39	24	27	55	0	0
(g) Select electrodes for job	64	39	24	37	9	21	0	3
(h) Postion for job	67	50	23	34	3	16	0	0
(i) Perform layout operations	46	50	51	34	3	16	0	0
(j) Fit up for job	58	55	42	37	0	3	0	5
(k) Machine cutting	21	24	46	34	30	42	0	0
(l) Repair welding machines	6	0	30	21	61	71	0	8
(m) Repair welding machine leads and grounds	27	31	46	24	27	45	0	0
(n) Programable welding burning equipment	9	2.5	52	37	39	58	0	2.5

(N.R. = no response)

This comparative table shows the regional and national percentage data to provide for easy comparison. Those functions considered necessary by over 37% of the regional and national respondents has included oxyacetylene gouging, arc gouging, select electrodes for job, perform layout operations, and fit up for the job. Those functions considered unnecessary by over 37%

of the respondents has included metal spraying and finishes, heat treating of metals, repair welding machines and the programable welding burning equipment. The region considered selecting electrodes for job and positioning for job more important by 17% or more percentage points. The national group has considered the heat treating of metals, selecting electrodes for the job and programable welding burning equipment, of considerable less importance than the regional respondents.

Question thirty-eight: This question has sought to determine the weld joints, weld position and weld processes most used by the welder and/or fitter.

The following chart shows the data in a graphic form whereby the reader may quickly discern those joints most used for a weld process and position. (The question thirty-eight chart is found on page 63.)

Question thirty-nine: Do you restrict your welders to the use of deposition techniques? Over 60% of both the regional and national respondents only restrict as required for each of the three deposition techniques. The comments for question thirty-nine are provided in Appendix B, Part V, p. 90.

TABLE

MANIPULATIVE SKILLS FOR A PRODUCTION WELDER AND/OR FITTER

38. In columns opposite each type of weld joint, select the positions you use the weld process.

SMAW- Shielded metal arc welding
GTAW- Gas tungsten arc welding
GMAW- Gas metal arc welding
FCAW- Flux core arc welding
SAW - Submerged arc welding

Weld joint types	Weld process	Flat		Hor-		Vert-		O/H	
		Reg.	Nat.	Reg.	Nat.	Reg.	Nat.	Reg.	Nat.
butt	SMAW	70%	63%	67%	74%	61%	68%	51%	60%
	GTAW	46%	68%	46%	68%	36%	60%	18%	40%
	GMAW	60%	79%	46%	71%	39%	63%	21%	37%
	FCAW	45%	71%	52%	58%	36%	47%	24%	29%
	SAW	34%	58%	3%	21%	3%	5%	0%	3%
lap	SMAW	61%	61%	64%	61%	49%	55%	45%	45%
	GTAW	33%	63%	33%	58%	30%	50%	18%	34%
	GMAW	46%	61%	43%	52%	24%	52%	18%	37%
	FCAW	49%	53%	46%	42%	33%	29%	27%	24%
	SAW	30%	37%	3%	16%	3%	0%	0%	0%
fillet	SMAW	67%	68%	67%	71%	60%	68%	51%	52%
	GTAW	39%	61%	36%	58%	36%	53%	21%	34%
	GMAW	52%	76%	36%	68%	27%	58%	18%	32%
	FCAW	55%	60%	46%	58%	36%	34%	24%	24%
	SAW	33%	39%	6%	16%	3%	3%	0%	3%
corner	SMAW	64%	58%	64%	58%	54%	53%	42%	47%
	GTAW	39%	66%	42%	63%	36%	58%	15%	34%
	GMAW	47%	63%	42%	47%	33%	53%	24%	29%
	FCAW	54%	50%	45%	34%	36%	34%	24%	21%
	SAW	30%	24%	3%	8%	0%	3%	0%	3%
edge	SMAW	58%	45%	55%	37%	51%	37%	42%	29%
	GTAW	36%	57%	30%	50%	30%	42%	21%	21%
	GMAW	42%	45%	30%	37%	18%	32%	15%	16%
	FCAW	51%	21%	45%	13%	39%	13%	24%	8%
	SAW	21%	13%	0%	0%	0%	0%	0%	0%

The above percentages were computed on the bases of those answering for each position, joint and process.

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Question forty has sought to determine what special persons write weld procedures within the industrial concerns. A graphic presentation has been provided to show more clearly those persons most used.

		(Regional)	(National)
(a)	Welding engineer	24%	68%
(b)	Technician	15%	32%
(c)	Engineer	24%	21%
(d)	Welding supervisor	30%	11%
(e)	Consultant firm	9%	8%
(f)	(Other) Quality assurance	18%	5%

The most used person to write welding procedures in the region was the welding supervisor while the welding engineer was most used throughout the nation. For comments see Appendix B, part VII, page 90.

FUTURE WELDING TRENDS

Question forty-one has sought to determine the weld processes most likely to increase, decrease or stay the same in the next decade.

The following graph will help to provide graphic data from which the reader may more quickly ascertain the expected outlook for each weld process.

Weld Process:	Increase		Decrease		Same		N.R.	
	Reg.	Nat.	Reg.	Nat.	Reg.	Nat.	Reg.	Nat.
(a) Oxyacetylene	6%	5%	55%	53%	32%	29%	18%	13%
(b) Metallic arc	18%	18%	33%	47%	21%	24%	30%	11%
(c) Gas metal arc (solid core)	49%	58%	12%	16%	15%	21%	24%	5%
(d) Gas metal arc (dual shield)	61%	63%	9%	8%	15%	18%	15%	11%
(e) Gas metal arc (inner shield)	27%	53%	9%	10%	37%	24%	27%	13%
(f) Tungsten inert gas arc	27%	53%	6%	5%	46%	29%	21%	13%
(g) Submerged arc	42%	47%	9%	5%	27%	32%	21%	16%
(h) Plasma arc	55%	74%	3%	0%	18%	21%	24%	5%
(i) Ultra sonic	27%	21%	6%	5%	21%	34%	45%	40%
(j) Oxy-fuel gas	9%	11%	24%	45%	36%	21%	30%	24%
(k) (other) Lazer and electron beam		13%						87%

(N.R. = no response)

From this chart most processes considered have relatively similar percentage values except gas metal arc (inner shield), tungsten inert gas arc and plasma arc wherein the national respondents felt these processes were more likely to increase. The national and regional respondents have shown differing responses as to whether the oxy-fuel gas process will decrease or stay the same. To these questions there were many giving no response.

Should welding schools be involved in teaching welder certification, code requirements and fabrication methods? Over 76% of the regional and national respondents consider welder certification and code requirements to be a function of the schools. Over 91% of both regional and national respondents felt the schools should be involved with the teaching of fabrication methods.

Question forty-three has sought to determine industrial response to cooperative industry-educational welding programs. Over 85% of the regional and 79% of the national respondents considered this necessary for the training of welders. The industrial respondents were also asked to list their suggestions for its implementation. The suggestions are provided in Appendix B, part VIII, pages 91-92.

Question forty-four has sought to determine the percentage of industry utilizing computerized cutting equipment. Of those responding to this question 33% of the regional and 34% of the national respondents use this type of equipment.

The use of robots is much discussed throughout American industry but the responses have indicated their usage to be 3% regionally and 10% nationally. There are comments to this question listed in Appendix B, part IX, pages 93-94.

CONCLUSIONS

1. The occupational ladder presented in 1974 and rechecked in 1984 has been accepted in part. The helper, welder journeyman, and the welder (special or supervisor) have been accepted by the majority of the regional industrial respondents. The limited tacker and the welder (instructor or engineer) were each accepted by a minority of the respondents.
2. Welder-fitters were accepted and hired by the majority of industry within Washington and Oregon.
3. The majority of the surveyed industrial concerns indicated their willingness to hire welder-fitters should they be trained by the vocational welding schools.
4. Entrance level welders are not hired directly from vocational training schools by a large percentage of the industry employing welders.
5. Entry level welder training was considered adequate by nearly as many industrial respondents as those who considered it inadequate for their industrial needs.
6. Certification requirement to some standard was required by the majority of industry hiring welders.
7. The majority of welders have a union affiliation.
8. A physical examination was required by slightly more than half of the industrial respondents.
9. Advertisements in local papers was considered the best method for the recruiting of welders.

10. Of those having general grade level requirements the high school was required by fifty percent within the region (only). Throughout the nation a large percentage of industry have no basic requirements on education.

11. Throughout the nation welders were principally trained by vocational schools.

12. The welders' basic education involving the scientific laws related to mechanics, mathematics, inter-personal skills related to the supervisory personnel and peer workers was considered desirable knowledge for all welders.

13. The welders' ability to communicate by receiving verbal communications, to verbally direct others, use written planning or procedure specification sheets was considered essential for the welder, but their ability to write reports was not considered necessary.

14. The welders' understanding of economics as related to employment, income and taxes, industrial organizations and family finance management was considered unnecessary.

15. The welder should be able to interpret and use welding related drawings and symbols but not the hydraulic or electrical.

16. Welders are required to be able to fit up parts for welding.

17. Welders are required to understand the metallurgical and welding characteristics of the common metals most used in construction and manufacturing.

18. An understanding of the heat treatment of metals involving annealing, normalizing, hardening and tempering was not considered necessary for the welder.

19. The welders' understanding of electricity as related to the AC-DC rectifier, motor-generator or the alternating current power source was considered desirable.

20. The welders' understanding of the metallurgical properties of metals when welded, design for welded structure, distortion control, affect of welding on heat treated metal and the testing and inspection processes was considered desirable knowledge for the welder.

21. The welders' understanding of the basic type joints and their characteristics when welded, welding terminology, methods of inspection or quality assurance and the awareness to hazardous fumes and gases was considered necessary.

22. Welding related cost factors, estimating costs, cutting of metals with respect to the various cutting processes and their limitations, codes and specifications was considered desirable knowledge for the welder.

23. Welders and/or fitters were expected to have skills in the operation of grinders and sanders, efficient use of small hand tools, jigs and fixtures, pneumatic tools, the rigging hoist or jib boom, the bridge crane (regional only) and hydraulic lift or fork trucks (regional only).

24. The skills welders were not expected to have include the use of taps, dies and reamers, hydraulic lift or fork truck

(national only), lathe, shaper, mill and other machining tools, press brake, punch, band saw, squaring shears and the nibbler.

25. The welder should be able to shape metals using the oxy-acetylene and arc gouging methods, select electrodes for the job, position for job, perform layout operations, and fit up for the job.

26. The skills welders were not expected to have include metal spraying and finishes, perform hard facing, heat treating of metals, select materials for the job, machine cutting, repair welding machines and the programming of welding burning equipment. The repairing of welding machine leads and grounds was considered a desirable skill for the welder.

27. Welders are restricted as to the welding technique used only as prescribed on engineering drawings.

28. Industry uses special persons to write out welding procedures.

29. The welding processes most likely to increase in usage included the gas metal arc (solid core), gas metal arc (dual and inner shield), gas tungsten arc, submerged arc and plasma arc.

30. Those welding processes thought to decline included oxy-acetylene, ultrasonic, oxy-fuel gas and metallic arc.

31. Welding schools should be involved in the teaching of welder certification, code requirements and fabrication methods.

32. Welding schools should be entering into more cooperative educational programs with industry.

33. The majority of the industrial concerns surveyed do not have computerized cutting or welding robots in their shops, but many are thinking and/or planning for them.

RECOMMENDATIONS

1. Due to the rapidity of economic changes within our nation, vocational schools must conduct periodic surveys to determine the acceptability of their graduates within their respective geographic areas of concern.
2. Vocational training schools teaching welding ought to broaden their curriculums to encompass the training requirements for the welder-fitter to provide for their acceptability within many industrial concerns.
3. The certification of welders is required by most industrial concerns, therefore the welding schools must be involved in certifying their graduates to some acceptable standard within their respective areas. They are to be cautioned to keep abreast of their regional industrial needs.
4. The high school diploma represents the minimum educational requirement for fifty percent (50%) of the regional industries so any potential student embarking upon a career in welding should seriously consider this requirement.
5. High school students anticipating a career in welding should take basic education classes involving the scientific laws of mechanics, mathematics, human relations, communications and economics related to employment and home.
6. Welders-fitters must expect to develop good communication skills to enable them to use written planning sheets, receive verbal communication and to verbally direct others.

7. Welders-fitters must understand the welding characteristics of basic type joints, welding terminology, methods of inspection or quality assurance and the awareness of hazardous fumes and gases.

8. Welders-fitters must understand the metallurgical properties of metals when welded, distortion control, and the affect of welding upon heat treated metals.

9. Welder-fitters must develop acceptable skills in the use of hand tools, grinders and sanders, jigs and fixtures, pneumatic tools, rigging, hoists or jib boom and the bridge crane.

10. Welder-fitters should expect to understand welding codes and specifications, metal cutting processes and their limitations, estimating costs and cost related factors.

11. Welder-fitters must be able to shape metal using the oxy-acetylene and arc gouging processes, select electrodes for the job, position and fit up for the job and perform layout operations.

12. Cooperative training involving vocational schools and all aspects of industry must expand their roles in the final training aspects of the welder-fitters thus bridging the gap between the school and industry. This will reduce many of the frustrations experienced by industry and the student.

13. Every vocational school teaching welding must develop a closer working relationship with their advisory committees to enable the schools to keep abreast of the welder-fitters industrial needs and the equipment and processes being used.

14. Some progress has been made, but Washington state needs to continue the development of an orderly process whereby well qualified, experienced welders may receive educational experiences including cadeting under the direction of qualified instructors enabling them to become vocational welding instructors. This procedure could be used to bring into education qualified persons in all areas of vocational training.

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6. "ERIC" computer search, University of Washington Libraries database references services, Seattle, Washington, July, 1984.

APPENDIX A, PART 1

COMMENTS MADE BY RESPONDENTS ON
PRELIMINARY LETTER OF INQUIRY AND QUESTIONNAIRE

Report of comments from industrial concerns willing to cooperate in an in-depth welding study.

QUESTION TWO

1. "Applicants are given a welding, fitting and cutting test. We do not do assembly line type work."

QUESTION THREE (no comments)

QUESTION FOUR

2. "Depends entirely on manpower available."

QUESTION FIVE

3. "Strictly on competition with all applicants."
4. "If work load required."
5. "Because of the decline in the steel fabrication industry in the Pacific Northwest over the last several years we have not had the opportunity to hire many new employees."
6. "Maybe, depending on needs."
7. "Union problems make this difficult."
8. "Only as apprentices."
9. "Very seldom."

QUESTION SIX

10. "Should teach them to read welding symbols - teach more automatic machine type welding - not stick."
11. "98% of our welding is FCAW and the students do not have enough training in this. They concentrate on stick (our area). I would like to see a longer course directed to blueprint, fitting, welding - fitter-welder."
12. "Very little training being done in wire welding."

13. "Be more specific with the different types of welding (Tig, Mig,Stick, Heliarc). Teach students how to adjust to welding different types of metal."

14. "The thrust should be toward inert shielding gas metal arc welding; i.e., FCAW, GMAW, GTAW, PAW. Subarc and some SMAW is essential. A knowledge of Robotics would be helpful."

15. "We hire through local unions."

16. "General welding education, particularly on wire."

17. "However more training is needed in the area of basic welding machine operation, equipment set up and trouble shooting."

18. "Lack of experience is difficult to overcome."

19. "If graduates aspire to be more than just bed-layers, they need more math."

20. "They do not know how to operate enough different "Brands" of machines, set up, etc."

21. "Basic training is adequate - the "real" training starts here."

22. "We could use welders with more hands-on experience with complicated prints and parts, machinery, etc."

23. "Welders on the whole need on-the-job training before they would be proficient."

24. "Need submerged Arc and TIG experience."

25. "I am not familiar with the welder-fitter curriculum at the vocational welding schools, but I am sure that practical experience goes hand-in-hand with class-shop instruction."

26. "We are an A.S.M.E. pressure vessel shop."

27. "At (Blank Company) all of our general repairmen are required to be proficient in mechanical repairs, pipe fitting and welding. We do not normally hire craftsman with only welding experience."

28. "Have not hired any."

29. "Welding in the field in wet weather."

30. "All of our welders are hired through the union."

31. "Most graduates we have interviewed are very weak in blueprint reading."

32. "Most graduates lack a working knowledge of blueprint interpretation without this in a fabrication shop, it is difficult to justify hiring beginners."

33. "Not enough training in lighter metals such as 14-16 guage, also brazing Ni-rod, etc."

34. "Basic skills only are required. All welders must certify to our weld procedures."

35. "Yes - more on symbols, blueprints, metallurgy and contemporary techniques."

36. "They can get the basics only."

37. "More training in the use of MIG welding, the use of a cutting torch, also how to read a tape measure."

38. "Welding skills seem to be adequate, blueprint and layout skills could be better. The main improvement that we would like to see is better training on what is expected productivity-wise of employees; i.e, "How much is a good days work"."

39. "Not having hired from a welder program, we cannot address this question."

40. "They need job shop experience before we can hire."

41. "Should have more background in steel grades and what could happen with too much or too little heat."

42. "Much seems to be lacking in the welding trade relating to the welding of precision sheet metal products."

43. "Emphasis on FCAW welding."

44. "Better print reading abilities, welding symbols, conversion of fractions to decimals equivalence of an inch and proper TIG welding teaching."

QUESTION SEVEN

45. "We are not big enough to have just tackers or welder-helpers."

46. "Our company employs one corporate M.F.G. engineer who is responsible for welding engineering."

47. "The above list applies only to high volume heavy production jobs. Job-shop shops require versatility - heavy plate welded to light sheet, lots of MIG, TIG, Stick, odd ball combinations, print reading & trigonometry. Drafting is much more valuable than print reading to a job-shop welder. Very little lay-out work can be done without Trig."

48. "Actually welding becomes incidental. Experience in design, fitting, fixturing, finish work and problem solving are most important."

49. "We only have helpers, apprentices, journeymen, leadmen and foreman."

50. "Utility person, helper, specialist, apprentice, welder-fitter, fitter-welder are the job categories related to our manufacturing ladder."

51. "At (blank) Company, due to the restrictive practices created by many separate job categories, we have found it best to have only (2) categories: journeyman welder and welder supervisor."

52. "Journeyman after 6,000 hour apprenticeship."

53. "Currently journeyman welders are readily available and the need for trainees is practically nil."

54. "A more direct training to the local industry, rather than a broad education in welding area, unless individual is involved in the educational aspects of welding."

55. "We have one job category for welders. They are basically doing production oriented wire feed welding."

56. "Since we are a production line manufacturing it is necessary that our welders be able to produce a strong accurate weld and also be able to perform in their duties in an efficient manner."

57. "At present we have two welders."

58. "The helper should be able to double as your tacker."

59. "Items D. & E., I would not be authorized to hire anyone in these categories, however our production welding is very low at this time."

60. "I understand our needs are not standard as many companies. We specialize in custom type machinery. An operator is given a blueprint and fits and welds assembly units and attaches or fits to machinery."

61. "I would be glad to help. I am on the executive board for A.W.S. PTCD section, incoming chairman and I serve on three advisory committees for College Industrial Departments."

62. "As the guy who hires welders, I am utterly flabbergasted at the low level of number skills demonstrated. Many are at a 4th or 5th arithmetic level. Few can think through the simplist of story problems."
"None of my "rookies" have but the vaguest idea how to fabricate when they leave school. Give them raw materials, tools, a fab, table, scrap steel for fixtures and a rack of clamps and they don't have the vaguest idea where to begin. Once the work is welded up, a grinder in their hands is a mutilating tool.
This is why I hire only the sharpest individuals. They can learn quickly and they can learn a lot on their own.
I administer a shop math test to all applicants and have learned a great deal from this. Feel free to call and discuss this with me if you're interested."

63. "I would be more than willing to help and improve our chances of getting people back into welding as a livelihood - good welders with a good knowledge and background are hard to come by."

64. "If we may be of some assistance please send the questionnaire. However, keep in mind we have only the one welding function at our company."

APPENDIX A, PART II

Comments from the "no" questionnaires

QUESTION ONE THROUGH FIVE (No comments)

QUESTION SIX

1. "Most schools are lacking in blueprint reading."

2. "We utilize only one journeyman welder who fulfills a wide variety of welding requirements for a production machine shop of 60-plus employees. We have not been able to utilize entry level welders in the past."

3. "The practical experience is short and hard to give, except on-the-job training."

QUESTION SEVEN

4. "We are a small job-shop and therefore need people that can do everything from a blueprint with very little assistance if any."

QUESTION EIGHT

5. "Having only one busy journeyman makes this rather impractical for us - our apologies."

6. "What welding our company does is field welding in connection with re-inforcing steel installations. We currently use "Iron workers Union-welders". These men are certified welders trained in Voc. schools, in apprentice classes or recertified in same schools. Cad. welding is the primary type of welding used, some arc. Two-thirds of union Iron workers are currently out of work."

7. "Our welders do standard manufacturing welding. We are striving for a production line efficiency. The mails are full of questionnaires that do not give the whole picture. I feel the instructors should acquire this information by visiting the different welding shops and factories and fill out their own forms."

GENERAL COMMENTS

8. "We do not weld at this facility."

9. "Continental Group, Inc., has permanently closed its plant at 601 S. Myrtle Street, Seattle, Wa. and moved the operation to West Chicago, Illinois."

10. "Sorry we could not be of help."

11. "I am in the field of Rubber/plastics and use machinists to make molds. I do not foresee hiring welders ever."

12. "We have to hire through the union."

13. "Do not employ welders. Regards."

14. "Our business does not apply to your inquiry."

15. "No welders anticipated in future."

16. "We don't hire any welders. The school's problem is the closed union shop. Personally I would prefer well trained, non-opinionated, desiring to learn, such as a good school would graduate."

APPENDIX A, PART III

Table Ia

I. Preliminary Questionnaires (general data)

- (1) Copies sent - 505
- (2) Copies returned
  - (a) yes - 62 (12%)
  - (b) no - 18 (4%)
  - (c) not delivered - 41 (8%)
- (3) Copies not returned - 387 (77%)
- (4) Additional copies sent to revised regional mailing list
  - (a) 47 extras

II. Welders' Regional Questionnaires

- (1) Copies sent - 109
- (2) Copies returned usable - 33 (30%)
- (3) Copies returned not usable - 1 (1%)
- (4) Copies not returned - 75 (69%)

III. Control Group (national)

- (1) Copies sent - 138
- (2) Copies returned usable - 38 (27%)
- (3) Copies returned not usable - 4 (3%)
- (4) Copies not returned - 96 (70%)

APPENDIX A, PART III

Table 1b

Tabulation of Preliminary Questionnaires.

Questionnaires sent - 505
returned - 80 (16%)
not delivered - 41 (8%)
not returned - 387 (77%)

Question one: Name of respondents not given.

(a) Yes - 60 (97%)
(b) No - 2 (3%)

Question two: Does your industrial concern hire welders?

(a) Yes - 61 (98.5%)
(b) No - 1 (1.5%)

Question three: Does your industrial concern employ welder-fitters?

(a) Yes - 48 (77%)
(b) No - 10 (16%)
(c) No response - 4 (7%)

Question four: What percentage of your welders are hired directly upon graduation?

(a) None - 36 (58%)
(b) 2% - 1 (1.5%)
(c) 8% - 5 (8%)
(d) 25% - 16 (26%)
(e) 50% - 0 (0%)
(f) 75% - 1 (1.5%)
(g) No response - 3 (5%)

Question five: Would you hire welder fitters if they were available from local welding schools?

Yes - 34 (55%)

No - 19 (31%)

Maybe - 5 (8%)

No response - 4 (6%)

Question six: Do you feel that entrance welders could be more adequately trained by the schools for your welding needs?

Yes - 44 or 71%

No - 10 or 16%

Maybe - 1 or 2%

No response - 7 or 11%

Question seven: Would you consider the following occupational ladder relevant in your industrial concern in 1984? (Please check those job categories relevant to your industry)

	Yes	No	No response
(a) Helper	38 (61%)	10 (16%)	4 (7%)
(b) Limited tacker	15 (24%)	29 (47%)	18 (29%)
(c) Welder (journeyman)	59 (95%)	1 (2%)	1 (2%)
(d) Welder (special or supervisor)	34 (55%)	12 (19%)	16 (26%)
(e) Welder (instructor or engineer)	13 (21%)	26 (42%)	23 (37%)

Question eight: Would you assist us by having a typical welder or welding supervisor fill out an in-depth questionnaire to provide current data from which our welding programs may be updated? (calculations are based upon returned questionnaires)

Yes	52 (86%)
No	7 (11%)
No response	3 (5%)

Of the industrial concerns responding to this question 86% were willing to cooperate further in an in-depth welding education study.

APPENDIX B, PART 1, 5a

Question five - Certification comments on Regional Questionnaires:

1. "Some or all of the above."
2. "In-house test is given."
3. "Classification is required for our fuel tank assembly .100 and .125 aluminum. 5052-H32 and 5086-H32."
4. "Welders are certified to ABS, Coast Guard or Military Standards."
5. "Not all welders need aluminum certification."
6. "We specialize in the welding of exotic metals."
7. "We require a written test on general welding and symbols, weld coupon test that is sectioned and analyzed."
8. "Fabrication here ranges from sheet metal to 14" thick."
9. "Some or all of the above."
10. "In-house is given."

APPENDIX B, PART 1, 5b

Question five - Certification comments on National Questionnaires:

1. "We set our own requirements more to process than to position."
2. "Certification is not required for employment but is required at completion of training."
3. "Ohio State Code for pipe welding."
4. "Varies according to assigned work area."
5. "Material form and thickness as well as material type depends on which shop welder will be in."

APPENDIX B, PART II, 9b

Question nine, Comments on welder recruiting (national):

1. "Company employment department - most are promoted and trained."
2. "Jobs are posted within the company for employee transfer from one department to another."
3. "Jobs are posted and other workers may bid for openings prior to hiring outside help."
4. "Jobs are bid by shop seniority - company provides training school."
5. "None of the above - always a back log of applicants for jobs."

APPENDIX B, PART III, 11a

Question eleven - Welder Training Schools (Regional)

1. "Only when previous experience was acquired in fabrication shops."
2. "Welder certification."
3. "In the past no, but it is becoming more apparent that vocationally trained welders are better trained than apprentice program graduates."
4. "Only for training positions."
5. "Need some production experience."
6. "Usually start in another job and gradually train into welding position."
7. "Need a little more job experience than just coming out of school."
8. "Not normally satisfactory."
9. "Trained in stick welding only."
10. "I have not hired anyone who has had vocational training."
11. "To date, best entry level workers have come from Boilermaker, Local 104 apprentice program or Renton Voc - Tech. school."

12. "As a general rule, we require precise on-the-job experience with related materials."

13. "We would like to see more training on production requirements and management skills. This would help build a base for someone to grow on."

14. "Welding is all they can do. Make things square is also a good skill, shop math is good to know also."

15. "Working experience is essential."

16. "Most training is on the job - for our high skills we have to train."

17. "Generally."

18. "They need on-the-job training."

19. "They need to have general working experience."

20. "Industrial experience is usually required."

APPENDIX B, PART III, 11b

Question eleven - Welder Training Schools (National)

1. "Most came from training centers."

2. "It helps but acquired skills are minimal."

3. "Welders do not know the technology that goes with the process. They trained as rod burners, not as welders."

4. "Spartanburg Tech. headed by Conrad Allan has a fine program in Spartanburg, S.C."

5. "Experienced welders are primarily sought, however, Daniels Construction Company (contractor) has school located on site for training and upgrading."

6. "We prefer some high school vocational training in welding but it is not mandatory."

7. "We do a lot of on-the-job training."

8. "Lack of metallurgical background in conjunction with welding."

9. "Basic welding - none or code work."

10. "We run our own training school."

11. "All welders must take a welding test depending on the procedure to be used on that particular job."

12. "Most vocational training high school students work part time before graduating and becoming full time employees."

13. "Testing requirements are rigid in addition to normal section IV tests, welders must exhibit ability to weld in difficult positions on I beam to plate tests. Many welders pass section IX test but fail visual on hangar I beam test.

14. "Most need additional training both to the process we use and to the way we use these processes."

15. "Specialized nature of our work requires significant on the job training."

16. "Many times they had necessary basics but were shocked at the speed required and the quality level - they spent too much time with cosmetics rather than functional requirements."

17. "Very little fabrication related knowledge and layout."

18. "Depends upon the school they attend. Some schools train their welders to pass our look see test."

19. "This depends on the area of assignment - many of our welders are assigned to precision areas and use laser, E.B., and GTAW processes. These people are generally selected from our internal welder population."

20. "Trained by C.E. regardless of previous training or experience. All welders must be qualified to codes, such as A.S.M.E."

APPENDIX B, PART IV, 16b

1. "Many of these courses would be great for welding technicians, but are impractical for production welders."

APPENDIX B, PART V, 38a

Question thirty-eight comments:

1. "All welds made in the flat or horizontal position with hard wire and 5% CO_2."

2. "(FCAW) is used for 95% of the welding done in our shop - alloy rods dual shield L.H."

APPENDIX B, PART V, 38b

Question thirty-eight comments (national):

1. "Positioners are used to change the angles of some joint designs to facilitate better welding or the use of a process, such as, (SAW)."

APPENDIX B, PART V, 39a

Question thirty-nine comments:

1. "Whichever is most applicable for size and position of weld."
2. "The deposition techniques are restricted only if called out by engineering."
3. "Vertical up only."
4. "We use MIG."
5. "We use the nest egg technique quite often on tool and die repair."

APPENDIX B, PART VI, 39b (national)

Question thirty-nine comments:

1. "How about forehand versus backhand."
2. "Most work is done to written procedures or under the direction of a welding engineer."

APPENDIX B, PART VII, 40a

Question forty comments:

1. "Welder supplier technical representative."
2. "Depending on materials and complexity."

APPENDIX B, PART VIII, 43a

Question forty-three comments:

1. "Most generally welders can pass weld tests plates but are lost when having to weld on fabrication. They need to weld in every day fabrication situation."
2. "Cooperative program with selected non-union plants that would work on an alternating work/study program by working one school team and going to school the next."
3. "Schools instead of generalizing should teach what local industries are doing."
4. "Questionnaire such as this should help."
5. "Keep abreast of welding field requirements and trends and train personnel in methods most demanded."
6. "Most manufacturing plants have training managers who should be contacted."
7. "Site visitation, work experience, exchange of fabrication blueprints to classroom for study."
8. "Field trips to shops to show students the real world of welding fabrication. Our shop is open."
9. "If company is thinking of hiring someone from school, that person should be more closely trained in company's own ways."
10. "If possible, but this does not seem practical with a small business like ours."
11. "Ask for advisory committee meetings with industry in the area."
12. "Placing welders in the industry would help them understand why they are being trained, it would also help them understand techniques while being in school."
13. "Instructors should visit various environments; i.e., pipe fab., fabrication of heavy equipment weldments, robots, etc."
14. "Through advisory boards."
15. "Have representatives talk to the various shops in industry."
16. "Touring manufacturing plants, maybe some on-the-job training."

APPENDIX B, PART VIII, 43b

Question forty-three comments on cooperative education:

1. "Coop. students working are observing typical tasks at a local build-shop, fabrication, etc."
2. "Form active craft advisory committees."
3. "Integrade coop. as the final requirement for program completion."
4. "Get local AWS section involved with assisting schools and employees to work with each other."
5. "Involve business in the education process. Do not establish advisory committees as a facade."
6. "Schools should set up AWS chapters and work with local AWS sections. AWS sections can help in setting up such cooperative programs.
7. "Welding schools need to contact or keep in touch with individuals in industry involved in welding."
8. "Welding schools (instructors) should be in close contact with local industry regarding how different processes are used."
9. "Industry steering committees are a must for all welding schools."
10. "Vocational schools should meet the need of local industry."
11. "Contact industry personnel to preview job sites and conditions of work, type of work, etc."
12. "Have a group of directors from various plants and construction."
13. "Industry donation of heavy weldments, 1" to 4" thick."
14. "Work study program-students work for reduced wage while gaining experience."
15. "Actively solicit industry for their needs and their financial support for the training."
16. "Format courses based upon what industry needs."
17. "Schools must stay in touch with industry by meeting industry in the field, plant tours and community meetings."

18. "On-the-job training experience."

19. "Work closer with employers."

20. "Just like student teachers, maybe some companies would have student welders."

21. "Recruit employees of local companies for an advisory board to make recommendations."

22. "Entry level welders are important to the nutrition of companies."

23. "Schools must give industry in their area welders trained to do what is needed."

APPENDIX B, PART IX, 45a

Question forty-five comments on welding robots:

1. "In process, the thing to watch."

2. "Computerized burner on list for next year's expenditure."

3. "Both items forty-four and forty-five must be in our future."

4. "I would imagine that in the very near future, I will have to go to some type of robots in order to be competitive."

5. "In-house training for all employees using audio visual; (FCAW), (GMAW), pre-heat and post-heat."

APPENDIX B, PART IX, 45b

Question forty-five comments on welding robots:

1. "Welding robot has been purchased, however, installation is not yet final."

2. "Several in production - more to come. Operators must monitor these systems both with eyes and ears. In robotic welding the welding process is generally used near the upper end of its operating range."

3. "In process of purchasing."

4. "Had two 'Unimate apprentices', robots at last shop in which I worked. Limited usefullness - excellent reliability."

5. "We do have dedicated welding automation, but not robots."

6. "Welding robots all are Puma-unimation and have been very productive. Only two weeks from delivery to full production on our first robot. Each job has at least replaced two people or more."

7. "For training at present."

APPENDIX B, PART X

General comments:

1. "I answered the questions pertaining to the welders we would be hiring from the union hall, but it is my opinion and to the benefit of the welders that all the answers should be desirable or even necessary to those questions."

2. "In this shop, though it was a union shop, everyone had to have the ability to take a job from the blueprints to finished product. They had no standard product so each job was something new. I gained an enormous amount of experience in fabrication which is a big help in relating to my customers as a welding supply salesman."

3. "On questions 12-38 I checked (D) desirable because if the person knows these items it is to his/her benefit, but still is not a requirement for employment. PEPCO offers a two-year apprenticeship program where all of these topics and more are taught. On certification they are not required for employment, but are expected at the completion of the training. All qualifications are to ASME code on pipe and tube, carbon steel, low alloy, stainless and inconel alloys."

4. "My best students continue their education by going to Hobart School, Ohio. We offer a two-year course in oxyacetylene welding, brazing and cutting-arc welding all positions up to 1" plate, Mig and Tig welding and Plasma arc cutting. One or two-year course is optional - all plates are bend tested except "NYS DOT."

5. "I run a development laboratory and the questions were answered with that perspective. It has provided a general view for about 25% of our welders."

APPENDIX C

List of Regional Industrial Concerns

1. Washington Iron Works
   Seattle, Washington 98134

2. Fishermans Boat Shop, Incorporated
   Everett, Washington 98201

3. Coe Manufacturing Company
   Tigard, Oregon 97223

4. Kenworth Truck Company
   Seattle, Washington 98108

5. Kaiser Aluminum and Chemical Corporation
   Spokane, Washington 99215

6. El. Jay-. Rock Crushing Company
   Eugene, Oregon 97215

7. Townmotor Corporation
   Dallas, Oregon 97338

8. Rovang and Associates, Incorporated
   Portland, Oregon 97217

9. Temco, Incorporated
   Clackamas, Oregon 97015

10. Electro Scientific Industries
    Portland, Oregon 97229

11. Cam Industries, Incorporated
    Kent, Washington 98032

12. Key Technology, Incorporated
    Milton - Freewater, Oregon 97862

13. R.A. Hanson Company
    Spokane, Washington 99207

14. Freightliner Corporation
    Portland, Oregon 97217

15. Duwamish Shipyard, Incorporated
    Seattle, Washington 98106

16. Todd Pacific Shipyard Corporation
    Seattle, Washington 98124

17. Rocket Research Corporation
Redmond, Washington 98052

18. Casey Enterprises, Incorporated
Albany, Oregon 97321

19. Graham Steel Corporation
Kirkland, Washington 98033

20. Ballard Ornamental Iron Works
Seattle, Washington 98107

21. Proctor Products Company, Incorporated
Kirkland, Washington 98033

22. Alaska Copper Works
Seattle, Washington 98124

23. Seidelhuber Iron Works
Seattle, Washington 9810[illegible]

24. Ideal Machine and Manufacturing, Incorporated
Tacoma, Washington 98411

25. Weyerhaeuser Company,
Kraft Mill
Everett, Washington 98206

26. Exotic Tool Welding
Everett, Washington 98204

27. Associate Sand and Gravel (Prestress)
Everett, Washington 98203

28. Cascade Corporation
Portland, Oregon 97220

29. WELDCO, Incorporated
Enumclaw, Washington 98022

30. Custom Steel Fabrication
Spokane, Washington 99219

31. Hyster Company
Portland, Oregon 97230

32. Wagner Mining Equipment
Portland, Oregon 97230

33. Atlas Iron Works
Portland, Oregon 97208

APPENDIX D

List of National Industrial Concerns

1. Lazer and Electric Beam, Manufacturing
   Clio, Michigan 48420
2. Newport News Shipbuilding
   Newport News, Virginia 23602
3. Heavy Equipment Fabrication
   Fanwood, New Jersey 07023
4. Mid-Mountain Contractors, Incorporated
   Bellevue, Washington 98009
5. Northern Welding Specialties
   Traverse City, Michigan 49684
6. Toledo Metal Fabricators
   Toledo, Ohio 43614
7. Utility
   Columbia, South Carolina 29206
8. Nuclear Power Plant Construction
   Charlotte, North Carolina 28211
9. Carolina Power and Light
   New Hill, North Carolina 27562
10. Babcock and Wilcox
    West Point, Mississippi 39773
11. Caterpillar Tractor Company
    Davenport, Iowa 52809
12. Gremada Industries, Incorporated
    West Fargo, North Dakota 58078
13. Plant Maintenance Service Corporation
    Memphis, Tennessee 38128
14. Ingalls Shipbuilding Corporation
    Pasagoula, Mississippi 39562
15. G.A. Power Company
    Fortson, Georgia 31808
16. Reynolds Metal Company
    Richmond, Virginia 23261

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17. Potomac Electric Power Company
Alexandria, Virginia 22310

18. Forma Scientific
Marrietta, Ohio 45750

19. L.T.V. Steel
Massilon, Ohio 44646

20. Rolock, Incorporated
Stevenson, Connecticut 06491

21. Stoughton Trailers, Incorporated
McFarland, Wisconsin 53558

22. Monsanto Company
Texas City, Texas 77590

23. A.L. Welding Products
Anchorage, Alaska 99502

24. Southwest Steel Fabricators, Incorporated
Desoto, Kansas 66018

25. G. H. Putman Welding and Fabrication
East Corinth, Vermont 05040

26. Paul Mueller, Company
Brookline, Missouri 65619

27. Tampa Shipyards, Incorporated
Tampa, Florida 33603

28. Electric Utility
Minneapolis, Minnesota 55415

29. Kawasaki Motors Corporation USA
Lincoln, Nebraska 68524

30. Westinghouse Electric
Sunnyvale, California 94086

31. The Lincoln Electric Company
Cleveland, Ohio 44117

32. Bristol Steel and Iron Works
Bristol, Virginia 24203

33. Public Vocational Area Schools
West Nysack, New York 10994

34. Chem-Tronics, Incorporated
Spring Valley, California 92022

35. Nuclear
Knoxville, Tennessee 37923

36. Rochester Gas and Electric
Rochester, New York 14649

37. C - E NATCO
Bakersfield, California 93303

38. Combustion Engineering Incorporated
Ooltewah, Tennessee 37363

APPENDIX E

Types of Products Manufactured by Regional Industries Represented Within Study

1. Cranes, wood product presses, logging equipment.
2. Marine related.
3. Wood products - plywood and sawmill machinery.
4. Class 8 trucks.
5. Aluminum sheet, plate, foil, extrusions.
6. Rock crushing equipment.
7. Lift trucks.
8. Stainless valves, pipe and tanks.
9. Air starter and air break vessels.
10. Electronics.
11. Equipment manufacturing - boilers, sand blasting equipment, packaging equipment, oil field pumpers and gas recovery equipment.
12. Equipment to service food processing industry.
13. Customized industrial machinery.
14. Class 8 trucks.
15. Shipbuilding, shop repair, conversion - tugs, fishing boats barges and heavy steel fabrication.
16. Ships.
17. Aerospace.
18. General steel fabrication, pressure vessels and tanks.
19. Structural steel.
20. Railings, doors, window grills, brackets and many small steel items.

21. Metal fabrication - precision sheet metal parts, structural and steel sheet metal fabrication, machinery and tool manufacturing.

22. Pressure vessels, heat exchangers - pipe spools.

23. Beams, columns, railings, stairs, gangways, pilings, etc.

24. Kraft (equipment) pulp.

25. Pre-stress and pre-cast concrete.

26. Lift truck attachments.

27. Logging and construction equipment.

28. Round plate fabrication, large pipe, tanks, penstocks, arming type tanks.

29. Fork lift trucks winches, straddle truck, compaction equipment.

30. Underground mining machines, scoops and trucks.

31. High rise and commercial buildings.

APPENDIX F

Types of Products Manufactured by National Industries Represented Within Study

1. Electron beam systems, lasers, mass spectrometer leak detection.
2. Aircraft carriers, submarines, commercial ship repair.
3. Steam generation and process equipment.
4. Cutting and welding of process piping - pre-fabricated piping.
5. Custom aluminum, stainless steel and magnesium fabrication and repair, tool and die, high pressure fittings.
6. Fabricated pressure vessels railroad car under carriages, pressure piping.
7. Electricity.
8. Nuclear piping, plate, pipe hangars, etc.,
9. Electric utility, nuclear plant construction department.
10. Boiler components.
11. Heavy metal fabrication - earth moving equipment.
12. Manufacturing caterpillar parts.
13. Pressure vessels - ASME code.
14. Ships.
15. Electric power.
16. All types of aluminum products.
17. Utility.
18. Laboratory equipment manufacturing.
19. Alloy steel and stainless steel.
20. Heat treating and chemical process equipment.
21. Semi-trailers.

22. Petro-chemicals.

23. Industrial gas and sell welding supplies (gas, O_2, N_2, C_2H_2).

24. Misc. Custom steel fabrications.

25. Welding job shop.

26. Food and beverage processing equipment - stainless steel.

27. Repair and building ships.

28. Electric utility.

29. Kawasaki motor vehicles, 3 wheel recreational vehicles, and Kawasaki jet skis.

30. Machinery manufacturing, marine propulsion equipment, missile launching systems.

31. Welding equipment.

32. Fabricated structural steel buildings and bridges.

33. Not listed.

34. Public vocational area school, West Nyack, N.Y.

35. Fabricate weapon components.

36. Electric power.

37. Heater treaters, separators, steam generator gas scrubbers, free water knockouts.

38. Pressure vessels and related equipment.

TABLE II

REGIONAL WELDER'S QUESTIONNAIRE DATA TABULATION

General Questions (1 through 11)

1. Respondents names are not given to secure their identity.

2. Alphabetized listing of industrial concerns presented within this study have been provided by Appendix C, page 95.

3. Products produced by the responding industries have been listed in Appendix E, Part I, page 100.

4. Welder entry level skill requirements:

(a) One year	10	or	30%
(b) 2 - 5 years	14	or	42%
(c) Journeyman	13	or	39%

5. Does your industry require certification testing?

(a) Yes	21	or	64%
(b) No	9	or	27%
(c) Both	3	or	9%

Part (a) If certification is required, please identify.

(1) Unlimited	11	or	33%
(2) Limited	17	or	52%

Part (b) Electrode types:

(1) E60XX	5	or	15%
(2) E70XX	14	or	42%
(3) Others	5	or	15%
(4) No response	14	or	37%

Part (c) Types of materials being welded:

Plate (steel):	17	or	51%
(1) 3/8 or less	12	or	36%
(2) 3/8 to 1"	13	or	39%
(3) 1" or above	13	or	39%
Pipe:	14	or	42%
(1) 1" or less	7	or	21%
(2) 1" to 6"	11	or	33%
(3) 6" and above	11	or	33%
(4) .020 and above 1"	1	or	3%
Sheetmetal	11	or	33%
Galvanized	5	or	15%
Stainless steel	15	or	46%
High alloy steel	10	or	30%
Aluminum	10	or	30%

Question five comments are provided in Appendix B, part I, page 86.

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TABLE II (continued)

6. Is your shop union affiliated?

yes	19	--	59%
no	13	--	41%

7. The average number of welders employed by the regional industries was 1118 welders.

8. Is a physical examination required for your welding personnel?

yes	17	--	52%
no	16	--	48%

9. By which of the following methods are your welding personnel recruited?

(a)	Union hall	8	--	24%
(b)	State employment service	10	--	30%
(c)	Private employment service	5	--	15%
(d)	Advertisement in local papers	18	--	56%
(e)	Welding schools	12	--	34%
(e)	(Other methods)	13	--	39%

Other methods included (a) word of mouth (b) applications taken at plant (c) walk in applicant (d) personal reference (e) plant employee referrals and (f) college employment offices. For comments see Appendix B, Part II, page 87.

10. Do you have any general education grade level requirements?

yes	13	--	39%
no	19	--	58%
no response	2	--	6%

If yes:	(1)	High school	10	--	30%
	(2)	College	1	--	3%
	(3)	Vocational technical school	7	--	21%
	(4)	Marked both high school and vocational technical	5	--	15%

11. Your welders were principally trained by:

(a)	Union trade schools	11	--	33%
(b)	Community college	12	--	36%
(c)	High school vocational training program	4	--	12%
(d)	Vocational schools	14	--	42%
(e)	Others included union or plant apprentice, experience, on the job training or unknown	5	--	15%

For comments see Appendix B, part III, page 87

TABLE II (Continued)

Respondents have circled their choice of response in the space provided whether it is necessary (N), desirable (D), or unnecessary (U) for welders to receive training in the following subject areas.

	Regional Industries		
Basic Education:	N	D	U
12. Inter-personal skills:			
(a) Welder - supervisory personnel	30%	42%	24%
(b) Welder - peer workers	24%	64%	12%
13. Basic understanding and application of scientific laws as related to mechanics: i.e. (levers).	18%	64%	18%
14. Mathematical problem solving ability encompassing arithmetic through basic algebra.	21%	49%	30%
15. Communications:			
(a) Write reports	9%	33%	52%
(b) Verbally direct others.	39%	55%	6%
(c) Receive verbal communication	85%	12%	0%
(d) Use written planning or procedure specification sheets	58%	33%	6%
16. Economic courses as related to:			
(a) Employment	3%	42%	55%
(b) Income and taxes	0%	27%	73%
(c) Industrial organizations	6%	49%	39%
(d) Family finance management	3%	39%	55%

For comments see Appendix B, part IV, page 89.

	N	D	U
Welding Related Knowledge Requirements:			
17. Interpret blueprints, shop drawings and welding symbols.	79%	21%	0%
18. Ability to make simple pictorial and three view drawings.	27%	55%	18%
19. Ability to interpret and use drawings related to hydraulic and pneumatic systems.	6%	42%	52%

TABLE II (continued)

		N	D	U
20.	Ability to interpret and use electrical drawings related to welding equipment.	3%	36%	61%
21.	Ability to fitup parts for welding.	79%	18%	0%
22.	Knowledge of the welding characteristic of:			
	(a) Carbon steel	70%	30%	0%
	(b) Alloy steels	52%	45%	3%
	(c) Stainless steel	51%	39%	15%
	(d) Aluminum alloys	42%	42%	21%
	(e) Titanium alloys	18%	39%	42%
	(f) Others included hastelloys, nickel, monels, copper, brass, bronze and nickel alloys.	0%	12%	6%
23.	Heat treatment of metals:			
	(a) Annealing	9%	61%	30%
	(b) Normalizing	9%	61%	30%
	(c) Hardening	12%	52%	36%
	(d) Tempering	9%	58%	33%
24.	Understanding of electricity as related to:			
	(a) AC-DC rectifier welding power source.	30%	58%	12%
	(b) Motor - generator power source	18%	64%	18%
	(c) Alternating current power source.	18%	70%	12%
25.	Metallurgical properties of metals as related to weldability, melting point, tensile strength, brittleness, yield point expansion and contraction.	18%	73%	9%
26.	Understanding of design of welded structure.	12%	85%	0%
27.	Understanding methods of distortion control.	48%	52%	0%
28.	Understanding of basic type joints and their characteristics when welded.	38%	12%	0%
29.	The affect of welding upon heat-treated metals.	46%	48%	3%
30.	Understanding of the terminology of welding.	76%	24%	0%
31.	Understanding of methods of inspection and/or quality assurance.	55%	24%	3%

TABLE II (continued)

		N	D	U
32.	Understanding of testing and inspection processes.	33%	61%	6%
33.	Understanding of welding related cost factors.	9%	82%	9%
34.	Understanding of estimating costs.	3%	67%	30%
35.	Production related:			
	(a) Understanding of the cutting of metals with respect to the various cutting processes and their limitations.	33%	61%	3%
	(b) Understanding of the codes and specifications related to welding; such as, pressure vessels, piping, building safety and etc..	27%	52%	27%
	(c) An awareness of hazardous fumes and gases when welding on certain metals.	73%	27%	0%

Welder and/or Fitter Related Skills and Functions.

		N	D	U
36.	Equipment operation:			
	(a) Press brake	12%	49%	39%
	(b) Punch	12%	58%	30%
	(c) Band saw	33%	48%	18%
	(d) Grinder and sanders	76%	24%	0%
	(e) Squaring Shears	15%	49%	36%
	(f) Nibblers	12%	49%	39%
	(g) Efficient use of small hand tools	73%	24%	3%
	(h) Lathe, shaper, mill, and other machining tools	3%	21%	73%
	(i) Jigs - fixtures	55%	39%	3%
	(j) Hydraulic lifts or fork trucks	46%	33%	21%
	(k) Pneumatic tools	52%	30%	18%
	(l) Taps, dies and reamers	39%	33%	27%
	(m) Rigging hoist or jib boom	52%	33%	15%
	(n) Bridge crane	54%	33%	12%
37.	Welding related functions:			
	(a) Oxyacetylene gouging	61%	24%	15%
	(b) Arc gouging	70%	30%	0%
	(c) Metal spraying and finishes	6%	33%	61%
	(d) Perform hardfacing	21%	49%	30%
	(e) Heat treating of metals	3%	58%	37%
	(f) Select materials for job	30%	39%	27%

TABLE II (continued)

37. Welding related functions: (continued)		N	D	U
(g)	Select electrodes for job	64%	24%	9%
(h)	Position for job	67%	23%	3%
(i)	Perform layout operations	46%	51%	3%
(j)	Fit up for job	58%	42%	0%
(k)	Machine cutting	21%	46%	30%
(l)	Repair welding machines	6%	30%	61%
(m)	Repair welding machine leads and grounds	27%	46%	27%
(n)	Programmable welding burning equipment	9%	52%	39%

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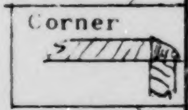
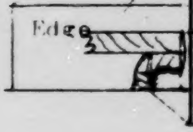
TABLE II (continued)

MANIPULATIVE SKILLS FOR A PRODUCTION WELDER AND/OR FITTER

38. In columns opposite each type of weld joint, select the positions you use the the weld process.

SMAW - Shielded metal arc welding
GTAW - Gas tungsten arc welding
GMAW - Gas metal arc welding
FCAW - Flux core arc welding
SAW - Submerged arc welding

Weld joint type	Weld processes	Flat Region	Horizontal Region	Vertical Region	O/H Region
Butt	SMAW	70%	67%	61%	51%
	GTAW	46%	46%	36%	18%
	GMAW	60%	46%	39%	21%
	FCAW	45%	52%	36%	24%
	SAW	34%	3%	3%	0%
Lap	SMAW	61%	64%	49%	45%
	GTAW	33%	33%	30%	18%
	GMAW	46%	43%	24%	18%
	FCAW	49%	46%	33%	27%
	SAW	30%	3%	3%	0
Fillet	SMAW	67%	67%	60%	51%
	GTAW	39%	36%	36%	21%
	GMAW	52%	36%	27%	18%
	FCAW	55%	46%	36%	24%
	SAW	33%	6%	3%	0%
Corner 	SMAW	64%	64%	54%	42%
	GTAW	39%	42%	36%	15%
	GMAW	47%	12%	33%	24%
	FCAW	54%	45%	36%	24%
	SAW	30%	3%	0%	0%
Edge 	SMAW	58%	55%	51%	42%
	GTAW	36%	30%	30%	21%
	GMAW	42%	30%	18%	15%
	FCAW	51%	45%	39%	24%
	SAW	21%	0%	0%	0%

The above percentages were compited on the basis of those answering for each position, joint and process.

TABLE II (continued)

39. Do you restrict your welders to the use of deposition techniques: such as,

	N%	D%	U%	NR%
(a) Stringer beads	18%	3%	67%	12%
(b) Weave	9%	9%	67%	28%
(c) Block	3%	6%	67%	25%

For comments see Appendix B, part VI, page 90.

40. Does your company use special persons to write welding procedures: If yes, please check: yes 91% no 6% NR 3%

(a) Welding supervisor	30%
(b) Technician	15%
(c) Engineer	24%
(d) Welding engineer	24%
(e) Consultant firm	9%
(f) Other - Q.A. Department	18%

For comments see Appendix B, part VII, page 90.

Future Welding Trends

41. Do you expect the use of the following weld processes to increase, decrease or stay the same in the next decade?

Weld Process	Increase	Decrease	Same	NR
(a) Oxyacetylene	6%	55%	32%	18%
(b) Metallic arc	18%	33%	21%	30%
(c) Gas metal arc (solid core)	49%	12%	15%	24%
(d) Gas metal arc (dual shield)	61%	9%	15%	15%
(e) Gas metal arc (inner shield)	27%	9%	37%	27%
(f) Tungsten inert-gas arc	27%	6%	46%	21%
(g) Submerged arc	42%	9%	27%	21%
(h) Plasma arc	55%	3%	18%	24%
(i) Ultra Sonic	27%	6%	21%	45%
(j) Oxy-fuel gas	9%	24%	36%	30%

42. Should welding schools be involved with teaching the following items:

	yes	no	NR
(a) Welder certification	85%	12%	3%
(b) Teaching of code requirements	76%	21%	24%
(c) Fabrication methods	91%	6%	3%

TABLE II (continued)

		yes	no	NR
13	Should welding schools enter into more cooperative educational programs with industry employing welders? if yes, please list suggestions for implementing.	85%	3%	12%

For comments see Appendix B, part VIII, page 91, 92.

		yes	no	NR
14.	Do you have computerized cutting equipment.	33%	64%	3%
15.	Do you have any welding robots in your shop? If yes, please list details:	3%	94%	3%

For comments see Appendix B, part IX, page 93.

TABLE III

NATIONAL WELDER'S QUESTIONNAIRE DATA TABULATION

General Questions (1 through 11)

1. To secure the respondents identity their names have not been given.

2. The industrial concerns have been provided in alphabetized listing in this study in Appendix D, page97.

3. The products produced by the industries cooperating in this study are provided in Appendix F, page 102.

4. Welder entry level skill requirements:

(a) Experience in years.

(1)	One year	16 or 42%
(2)	2 - 5 years	11 or 29%
(3)	Journeymen	8 or 21%
(4)	Misc. answers	2 or 5%
(5)	No response	5 or 14%

(*) (some respondents marked more than one answer)

5. Does your industrial concern require certification testing?

yes	27 or 71%
no	7 or 18%
no response	4 or 11%

(a) If certification is required please identify:

(1)	Unlimited	22 or 60%
(2)	Limited	7 or 18%

(b) Electrode types:

(1)	E60XX	11 or 29%
(2)	E70XX	23 or 61%
(3)	Other materials	9 or 24%
(4)	NO response	1 or 2.6%

(c) Material types:

(1)	Plate:	23 or 61%
	3/8 or less	13 or 34%
	3/8 or more	17 or 45%
	1" or above	13 or 34%
(2)	Pipe:	25 or 66%
	1" and less	12 or 32%
	1" to 6"	19 or 50%
	6' or above	18 or 47%

(Percentages based upon 38 respondents)

TABLE III (continued)

General Questions (1 through 11) (continued)

(3) Other materials:

Sheetmetal	8	or	21%
Galvanized	6	or	16%
High alloy steel	16	or	42%
Stainless steel	22	or	58%
Aluminum	15	or	40%
Other high alloy steels	2	or	6%

See comments in Appendix B, part I, II, & III, pages 86,87.

6. Is your shop union affiliated?

yes	22	or	58%
no	15	or	40%
no response	1	or	2%

7. Monthly average number of welders employed by the national respondents reporting totalled 6973 welders.

8. Is a physical examination required for your welding personnel?

yes	27	or	71%
no	11	or	29%

9. By which of the following methods are your welding personnel recruited?

(a)	Union halls	9	or	24%
(b)	State employment service	10	or	26%
(c)	Private employment service	3	or	8%
(d)	Advertisements in local papers	19	or	50%
(e)	Welding schools	12	or	32%
(f)	Other methods used:	13	or	34%

(1) Personal contact (2) Bidding in house (3) General on the job training (4) Walk in applicants (5) High school or college programs.

Comments have been provided in Appendix B, part II, pages 87.

10. Do you have any general education grade level requirements? If yes, please list.

yes	18	or	47%
no	17	or	44%

(a)	High school	19	or	50%
(b)	College	1	or	3%
(c)	Vocational technical school	5	or	13%

TABLE III (continued)

11. Your welders were trained principally by:

(a) (1)	Union trade schools	5	or	11%
(2)	Community colleges	7	or	18%
(3)	High school vocational programs	11	or	29%
(4)	Vocational schools	19	or	50%
(5)	Others included:	5	or	13%

(a) Company training schools, (b) On the job, (c) Other companies.

(b) Was vocational training adequate for your entry level workers. There were 40% of the national respondents that considered it adequate and 39% inadequate.

For comments to this question see Appendix B, part III, page 87,88.

Basic Education:

		N	D	U	NR
12.	Inter - personal skills:				
	(a) Welder - supervisory personnel	18%	61%	16%	5%
	(b) Welder - peer workers	26%	56%	11%	5%
13.	Basic understanding and application of scientific laws as related to mechanics; i.e. (levers)	8%	63%	21%	11%
14.	Mathematical problem solving ability encompassing arithmetic through basic algebra.	21%	50%	26%	3%
15.	Communications:				
	(a) Write reports	3%	29%	63%	5%
	(b) Verbally direct others	18%	66%	16%	0%
	(c) Verbally receive communication	87%	10%	0%	3%
	(d) Use written planning or procedure specifications	68%	26%	3%	3%
16.	Economics courses as related to:				
	(a) Employment	8%	32%	55%	5%
	(b) Income and taxes	2.5%	29%	66%	2.5%
	(c) Industrial Organizations	0%	50%	47%	3%
	(d) Family finance management	5%	32%	60%	3%

Comments provided in Appendix B, part IV, page 89.

TABLE III (continued)

Welding Related Knowledge Requirements

	N	D	U	NR
17. Interpret blueprints, shop drawings and welding symbols.	71%	26%	0%	3%
18. Ability to make simple pictorial and three view drawings.	16%	55%	29%	0%
19. Ability to interpret and use drawings related to hydraulic and pneumatic systems.	10%	24%	66%	0%
20. Ability to interpret and use electrical drawings related to welding equipment.	5%	35%	55%	5%
21. Ability to fit up parts for welding.	60%	29%	3%	8%
22. Knowledge of welding characteristics of:				
(a) Carbon steel	68%	21%	3%	3%
(b) Alloy steel	58%	29%	8%	5%
(c) Stainless steels	60%	27%	10%	3%
(d) Aluminum alloys	29%	42%	26%	3%
(e) Titanium alloys	0%	50%	42%	8%
(f) Others included 16%				

The other materials represented by part (f) include (1) Nickel alloys, (2) Silicon bronze, (3) Cast, (4) Inconel, (5) Hard facing.

	N	D	U	NR
23. Heat treatment of metals:				
(a) Annealing	5%	42%	47%	6%
(b) Normalizing	5%	39%	53%	3%
(c) Hardening	3%	39%	53%	5%
(d) Tempering	3%	42%	47%	8%
24. Understanding of electricity as related to:				
(a) AC-DC rectifier welding power source.	10%	36%	21%	3%
(b) Motor generator power source.	5%	58%	37%	0%
(c) Alternating current power source.	8%	58%	31%	3%
25. Metallurgical properties of metals as related to weldability, melting point, tensile strength, brittleness, yield point, expansion, and contraction.	16%	61%	18%	5%

TABLE III (continued)

		N	D	U	NR
26.	Understanding of design for welded structures.	16%	50%	31%	3%
27.	Understanding methods of distortion control.	42%	50%	3%	5%
28.	Understanding of basic type joints and their characteristics when welded.	63%	34%	0%	3%
29.	The affect of welding upon heat-treated metals.	32%	45%	21%	3%
30.	Understanding of the terminology of welding.	60%	29%	3%	8%
31.	Understanding of methods of inspection and/or quality assurance.	42%	50%	5%	3%
32.	Understanding of testing and inspection processes.	21%	60%	16%	3%
33.	Understanding of welding related cost factors.	8%	63%	29%	0%
34.	Understanding of estimating costs.	0%	52%	45%	3%
35.	Production related:				
	(a) Understanding of the cutting of metals with respect to the various cutting processes and their limitations.	32%	47%	21%	0%
	(b) Understanding of the codes and specifications related to welding; such as, pressure vessels, piping, safety and etc..	18%	47%	32%	3%
	(c) An awareness of hazardous fumes and gases when welding on certain metals.	63%	34%	0%	3%

Welder and/or Fitter related Skills and Functions

		N	D	U	NR
36.	Equipment operation:				
	(a) Press brake	8%	34%	55%	3%
	(b) Punch	13%	26%	58%	3%

TABLE III (continued)

Welder and/or Fitter Related Skills and Functions

36.	Equipment Operation: (continued)	N	D	U	NR
(c)	Band saw	26%	[illegible]	32%	3%
(d)	Grinders and sanders	71%	18%	8%	3%
(e)	Squaring shears	18%	32%	50%	0%
(f)	Nibbler	10%	37%	50%	3%
(g)	Efficient use of small hand tools	74%	21%	2.5%	2.5%
(h)	Lathe, shaper, mill and other machining tools	5%	18%	71%	5%
(i)	Jigs and fixtures	45%	47%	8%	0%
(j)	Hydraulic lifts or fork trucks	18%	40%	42%	0%
(k)	Pneumatic tools	42%	37%	18%	3%
(l)	Taps, dies and reamers	13%	40%	42%	5%
(m)	Rigging hoist or jib boom	39%	24%	34%	3%
(n)	Bridge crane	32%	16%	45%	7%

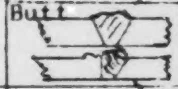
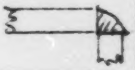
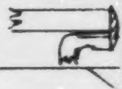
37.	Welding related functions:				
(a)	Oxyacetylene gouging	37%	24%	34%	5%
(b)	Arc gouging	60%	24%	1.3%	3%
(c)	Metal spraying and finishes	5%	21%	66%	8%
(d)	Perform hardfacing	21%	31%	45%	3%
(e)	Heat treating of metals	8%	37%	55%	0%
(f)	Select materials for job	21%	24%	55%	0%
(g)	Select electrodes for job	39%	37%	21%	3%
(h)	Position for job	50%	34%	16%	0%
(i)	Perform layout operations	50%	34%	16%	0%
(j)	Fit up for job	55%	37%	3%	5%
(k)	Machine cutting	24%	34%	42%	0%
(l)	Repair welding machines	0%	21%	71%	8%
(m)	Repair welding machine leads and grounds	31%	24%	45%	0%
(n)	Programable welding burning equipment	2.5%	37%	58%	2.5%

TABLE III (Continued)

MANIPULATIVE SKILLS FOR A PRODUCTION WELDER AND/OR FITTER

38. In columns below each type of weld joint, select the position you use the weld process.

SMAW - Shielded metal arc welding
GTAW - Gas tungsten arc welding
GMAW - Gas metal arc welding
FCAW - Flux core arc welding
SAW - Submerged arc welding

Weld joint type	Welding Process	Flat National	Horizontal National	Vertical National	O/H National
Butt 	SMAW	63%	74%	68%	60%
	GTAW	68%	68%	60%	40%
	GMAW	79%	71%	63%	37%
	FCAW	71%	58%	47%	29%
	SAW	58%	21%	5%	3%
Lap	SMAW	61%	61%	55%	45%
	GTAW	63%	58%	50%	34%
	GMAW	61%	52%	52%	37%
	FCAW	53%	42%	29%	24%
	SAW	37%	16%	0%	0%
Fillet	SMAW	68%	71%	68%	52%
	GTAW	61%	58%	53%	34%
	GMAW	76%	68%	58%	32%
	FCAW	60%	58%	34%	24%
	SAW	39%	16%	3%	3%
Corner 	SMAW	58%	58%	53%	47%
	GTAW	66%	63%	58%	34%
	GMAW	63%	47%	53%	29%
	FCAW	50%	34%	34%	21%
	SAW	24%	8%	3%	3%
Edge 	SMAW	45%	37%	37%	29%
	GTAW	57%	50%	42%	21%
	GMAW	45%	37%	32%	16%
	FCAW	21%	13%	13%	8%
	SAW	13%	0%	0%	0%

(Percentages based upon 38 respondents)

These percentages represent the industries responding to this question. Comments provided in Appendix B part V , pages 89,90.

TABLE III (continued)

Manipulative Skills for a Production Welder and/or Fitter

39. Do you restrict your welders to the use of deposition techniques: such as,

		always	never	only as required	NR
(a)	Stringer beads	16%	2.5%	79%	2.5%
(b)	Weave	5%	3%	84%	8%
(c)	Block	5%	11%	60%	24%

Comments provided in Appendix B, part VI , page 90 .

40. Does your company use special persons to write welding procedures? If yes, please check.

yes	89%
no	3%
NR	8%

*(a)	Welding supervisor	4	or	11%
(b)	Technician	12	or	32%
(c)	Engineer	8	or	21%
(d)	Welding engineer	26	or	68%
(e)	Consultant firm	3	or	8%
(f)	Welding Q.C. supervisor	2	or	5%

* (Some industries use more than one special person to write weld procedures.)

Future Welding Trends

41. Do you expect the use of the following weld processes to increase, decrease or stay the same in the next decade?

	Weld process:	increase	decrease	same	NR
(a)	Oxyacetylene	5%	53%	29%	13%
(b)	Metallic arc	18%	47%	24%	11%
(c)	Gas metal arc (solid core)	58%	16%	21%	5%
(d)	Gas metal arc (dual shield)	63%	8%	18%	11%
(e)	Gas metal arc (inner shield)	53%	10%	24%	13%
(f)	Tungsten inert gas arc	53%	5%	29%	13%
(g)	Submerged arc	47%	5%	32%	16%
(h)	Plasma arc	74%	0%	21%	5%
(i)	Ultra sonic	21%	5%	34%	40%
(j)	Oxy - fuel gas	11%	45%	21%	24%
(k)	Other - Laser and electron beam	13%			

TABLE III (continued)

Future Welding Trends (continued)

	yes	no	NR
42. Should welding schools be involved in teaching the following items:			
(a) Welder certification	87%	10%	3%
(b) Teaching of code requirements	82%	13%	5%
(c) Fabrication methods	95%	0%	5%
43. Should welding schools enter into more cooperative educational programs with industry employing welders? If yes, please list suggestions for implementing.	79%	11%	10%
Comments provided in Appendix B, part VIII, page 91,92.			
44. Do you have computerized cutting equipment?	34%	63%	3%
45. Do you have any welding robots in your shop? If yes, please list details.	10%	87%	3%
See Appendix B, part IX page 93.			

APPENDIX G
Part I

Everett Community College

PRELIMINARY LETTER OF INQUIRY AND QUESTIONNAIRE

June 3, 1984

To enable schools of welding to reflect industrial changes, an indepth study of welding technology and the welder's task is essential.

In pursuit of this goal, I am initiating a study of the welder's tasks as reported by the welding industry in the Pacific Northwest. If you employ welders and feel that they should be more adequately trained, will you please assist in this study by responding to this preliminary questionnaire of inquiry in the affirmative and return it to us.

This writer in cooperation with the Everett Community College welding department personnel and administration is conducting this follow-up research to ascertain the current reliability of our curriculums as to industrial needs.

Please return this questionnaire in the self-addressed stamped envelope prior to July 1, 1984.

Thank you for your cooperation in this project.

Sincerely,

Charles F. Bacon

Charles F. Bacon

801 Wetmore Avenue · Everett Washington 98201 · (206) 259-7151

APPENDIX G Part I
(2)

PRELIMINARY QUESTIONNAIRE

1. Please give any name and address correction required and person to whom this correspondence should be directed within your industry.

____

____

____

2. Does your industrial concern employ welders? yes ___ no ___

3. Does your industrial concern employ welder-fitters? yes ___ NO ___

4. What percentage of your welders are hired directly upon graduation from vocational welding schools? ( ) 25% ( ) 50% ( ) 75% or ( ) none

5. Would you hire welder-fitters if they were available from local welding schools? yes ___ no ___

6. Do you feel that entrance welders could be more adaquately trained by the schools for your welding needs? yes ___ no ___
(comments) ____

____

____

____

7. Would you consider the following occupational ladder relevant in your industrial concern in 1984? Please check those job catagories relevant to your industry.

a. Helper -- yes ___ no ___
b. Limited tacker ---------------------------------- yes ___ no ___
c. Welder (journeyman) -------------------------------- yes ___ no ___
d. Welder (special or supervisor) ------------------- yes ___ no ___
e. Welder (instructor or engineer) ----------------- yes ___ no ___
(comments) ____

____

____

____

8. Would you assist us by having a typical welder or welding supervisor fill out an indepth questionnaire to provide current data from which our welding curriculum may be updated? -------------- yes ___ no ___

(comments) ____

____

____

____

____

____

____

____

To whom should the indepth questionnaire be addressed? ______________

____

____

____

Thank you.

APPENDIX G

Part II

Everett Community College

COVER LETTER REGIONAL INDUSTRIES WHO DID NOT RESPOND TO THE PRELIMINARY QUESTIONNAIRE

July 31, 1984

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To enable schools of welding to reflect industrial changes, an indepth study of welding technology and the welder's task is essential.

In pursuit of this goal, I am initiating a study of the welder's tasks as reported by the welding industry in the Pacific Northwest. If you employ welders will you please assist in this study by filling out this questionnaire and returning it to me.

This writer in cooperation with the Everett Community College welding department personnel and administration is conducting this follow-up research to ascertain the current reliability of our curriculums as to industrial needs.

Please return this questionnaire in the self-addressed stamped envelope.

Thank you for your cooperation in this project.

Sincerely,

Charles F Bacon

Charles F. Bacon

801 Wetmore Avenue · Everett Washington 98201 · (206) 259-7151

APPENDIX G

Part III

Everett Community College

COVER LETTER SENT WITH THE QUESTIONNAIRE MAILED TO ALL A.W.S. REGIONAL PRESIDENTS

July 31, 1984

To enable schools of welding to reflect industrial changes, an indepth study of welding technology and the welder's task is essential.

In pursuit of this goal, I am initiating a study of the welder's tasks as reported by the welding industry in the United States. If you employ welders will you please assist in this study by filling out this questionnaire and returning it to me.

This writer in cooperation with the Everett Community College Welding department personnel and administration is conducting this follow-up research to ascertain the current reliability of our curriculums as to industrial needs.

Please return this questionnaire in the self-addressed stamped envelope that I may complete this study.

Thank you for your cooperation in this project.

Sincerely,
Charles F Bacon
Charles F. Bacon

801 Wetmore Avenue · Everett Washington 98201 · (206) 259-7151

APPENDIX G

Part IV

Everett Community College

QUESTIONNAIRE, SHEET ONE SENT TO ALL A.W.S.
REGIONAL PRESIDENTS

Dear Sir:

Your cooperation in this study is essential and will be greatly appreciated. Should you desire, a summary of this research will be provided you upon its completion.

yes ____ no ____

Thank you,
Charles F. Bacon
Charles F. Bacon

****

GENERAL INFORMATION:

Are you the same person named above? If no, yes ___ no ___

1. Please list respondents name. ____________________

2. Name of industry ____________________

3. Type of products manufactured by your industry? ____________________
____

4. Welder entry level skill requirements:
   a. Experience (years) ( ) 1 year ( ) 2-5 years ( ) journeyman

5. Does your industry require certification testing? yes ___ no ___
   a. If certification is required please identify:
      ( ) unlimited, or ( ) limited position
   b. ( ) E60XX ( ) 70XX electrode types
   c. ( ) plate
      ( ) 3/8 or less
      ( ) 3/8 to 1"
      ( ) 1" or above
      ( ) pipe
      ( ) 1" and less
      ( ) 1" to 6"
      ( ) 6" and above
      ( ) sheetmetal
      ( ) galvanized
      ( ) high alloy steel
      ( ) stainless steel
      ( ) aluminum
   (comments) ____________________
   ____

6. Is your shop union affiliated? ---------------------- yes ___ no ___

7. Number of welders employed ---------------------- (average monthly)

8. Is a physical examination required for your welding personnel?
   yes ___ no ___

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APPENDIX G

Part V

Everett Community College

QUESTIONNAIRE, SHEET ONE SENT TO COOPERATIVE INDUSTRIES WHO FILLED OUT THE PRELIMINARY QUESTIONNAIRE

Thank you for filling out the preliminary questionnaire dated June 1, 1984, and returning it to me.

In the returned response from my preliminary questionnaire you indicated your interest and desire to cooperate in my curriculum study.

Your cooperation in this study is essential and will be greatly appreciated. Should you desire, a summary of this research will be provided you upon its completion.

yes ___ no ___

Thank you,
Charles F. Bacon
Charles F. Bacon

****

GENERAL INFORMATION:

Are you the same person named above? If no, yes ___ no ___

1. Please list respondents name. ______________________________

2. Name of industry ______________________________

3. Type of products manufactured by your industry? ______________________________
____

4. Welder entry level skill requirements:
   a. Experience (years) ( ) 1 year ( ) 2-5 years ( ) journeyman

5. Does your industry require certification testing? yes ___ no ___
   a. If certification is required please identify:
      ( ) unlimited, or ( ) limited position
   b. ( ) E60XX ( ) 70XX electrode types
   c. ( ) plate
      ( ) 3/8 or less
      ( ) 3/8 to 1"
      ( ) 1" or above
      ( ) pipe
      ( ) 1" and less
      ( ) 1" to 6"
      ( ) 6" and above
      ( ) sheetmetal
      ( ) galvanized
      ( ) high alloy steel
      ( ) stainless steel
      ( ) aluminum
   (comments) ______________________________
   ____

6. Is your shop union affiliated? ---------------------- yes ___ no ___

7. Number of welders employed ---------------------- (average monthly)

8. Is a physical examination required for your welding personnel?
   yes ___ no ___

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APPENDIX H
(2)

9. By which of the following methods are your welding personnel recruited?

( ) Union halls ( ) Advertisements in local papers
( ) State employment service ( ) Welding schools
( ) Private employment service( ) If other, please list ____________

____

____

10. Do you have any general education grade level requirements. yes___ no ___
If yes, please list. High school ( ), College ( ) or Voc. Tech Schl.( )

11. Your welders were trained principally by:
a. ( ) Union trade schools ( ) High school vocational program
( ) Community college ( ) Vocational schools
( ) Other ____

____

.b. Was vocational training adequate for your entry level workers?
yes ___ no ___
(comments) ____

____

____

DIRECTIONS: (For the following section of questionnaire).

Evaluate the following statements for their importance to your prospective employees.

Circle your choice of response in the space provided whether it is necessary (N), desirable (D), or unnecessary (U), for welders to receive training in the following subject areas.

EXAMPLE:

1. Ability to make a butt weld. [✓ N] D U

BASIC EDUCATION:

12. Inter-personal skills:
a. Welder - supervisory personnel ---------------------- N D U
b. Welder - peer workers --------------------------------- N D U

13. Basic understanding and application of scientific laws as related to mechanics: i.e. (levers). ---------------- N D U

14. Mathematical problem solving ability encompassing arithmetic through basic algebra. ---------------------------- N D U

15. Communications:
a. Write reports -- N D U
b. Verbally direct others -------------------------------- N D U
c. Receive verbal communications ---------------------- N D U
d. Use written planning or procedure specification sheets N D U

16. Economics courses as related to:
a. Employment -- N D U
b. Income and taxes -------------------------------------- N D U
c. Industrial organizations ------------------------------ N D U
d. Family finance management ---------------------------- N D U

WELDING RELATED KNOWLEDGE REQUIREMENTS:

17. Interpret blueprints, shop drawings and welding symbols. N D U

18. Ability to make simple pictorial and three view drawings. N D U

19. Ability to interpret and use drawings related to hydraulic and pneumatic systems. ---------------------------------- N D U

20. Ability to interpret and use electrical drawings related to welding equipment. ------------------------------------- N D U

21. Ability to fitup parts for welding. ------------------- N D U

22. Knowledge of the welding characteristics of:
    a. Carbon steels -- N D U
    b. Alloy steels --- N D U
    c. Stainless steels --------------------------------------- N D U
    d. Aluminum alloys -- N D U
    e. Titanium alloys -- N D U
    f. Others --- N D U
    -- N D U

23. Heat treatment of metals:
    a. Annealing -- N D U
    b. Normalizing -- N D U
    c. Hardening -- N D U
    d. Tempering or drawing ----------------------------------- N D U

24. Understanding of electricity as related to:
    a. AC-DC rectifier welding power source ------------------ N D U
    b. Motor-generator power source -------------------------- N D U
    c. Alternating current power source ---------------------- N D U

25. Metallurgical properties of metals as related to weldability, melting point, tensile strength, brittleness, yield point, expansion, and contraction. --------------- N D U

26. Understanding of design for welded structure. ---------- N D U

27. Understanding methods of distortion control. ----------- N D U

28. Understanding of basic type joints and their characteristics when welded. ------------------------------------ N D U

29. The affect of welding upon heat-treated metals. -------- N D U

30. Understanding of the terminology of welding. ----------- N D U

31. Understanding of methods of inspection and/or quality assurance. --- N D U

32. Understanding of testing and inspection processes. ----- N D U

33. Understanding of welding related cost factors. --------- N D U

34. Understanding of estimating costs. --------------------- N D U

35. Production related:
    a. Understanding of the cutting of metals with respect to the various cutting processes and their limitations. N D U

    b. Understanding of the codes and specifications related to welding; such as, pressure vessels, piping, building safety, and etc.. ---------------------------- N D U

    c. An awareness of hazardous fumes and gases when welding on certain materials. ---------------------------- N D U

WELDER AND/OR FITTER RELATED SKILLS AND FUNCTIONS:

36. Equipment operation:

a. Press brake	N	D	U	i. Jigs - fixtures	N	D	U
b. Punch	N	D	U	j. Hydraulic lifts or fork trucks	N N	D D	U U
c. Band saw	N	D	U	k. Pneumatic tools	N	D	U
d. Grinders and sanders	N	D	U	l. Taps, dies, and reamers	N	D	U
e. Squaring shears	N	D	U	m. Rigging hoist or jib boom	N	D	U
f. Nibbler	N	D	U	n. Bridge crane	N	D	U
g. Efficient use of small hand tools	N	D	U	o. Other	N	D	U
h. Lathe, shaper, mill, and other machining tools	N	D	U	p. Other	N	D	U

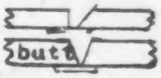
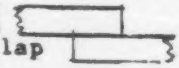
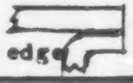
37. Welding related functions:

a. Oxy-acetylene gouging	N	D	U	h. Position for job	N	D	U
b. Arc gouging	N	D	U	i. Perform layout operation	N	D	U
c. Metal spraying and finishes	N	D	U	j. Fit up for job	N	D	U
d. Perform hardfacing	N	D	U	k. Machine cutting	N	D	U
e. Heat treating of metals	N	D	U	l. Repair welding machines	N	D	U
f. Select materials for job	N	D	U	m. Repair welding machine leads and grounds	N	D	U
g. Select electrodes for job	N	D	U	n. Programable welding burning equipment	N	D	U
				o. Other	N N	D D	U U

MANIPULATIVE SKILLS FOR A PRODUCTION WELDER AND/OR FITTER:

38. In columns below each type of weld joint, select the positions you use the weld process.

SMAW - Shielded metal arc welding
GTAW - Gas tungsten arc welding
GMAW - Gas metal arc welding
FCAW - Flux core arc welding
SAW - Submerged arc welding

Weld joint types																									
Welding process	SMAW	GTAW	GMAW	FCAW	SAW	SMAW	GTAW	GMAW	FCAW	SAW	SMAW	GTAW	GMAW	FCAW	SAW	SMAW	GTAW	GMAW	FCAW	SAW	SMAW	GTAW	GMAW	FCAW	SAW
Flat																									
Hor-																									
Vert-																									
O/H																									
*N/A																									

*(not applicable)

39. Do you restrict your welders to the use of deposition techniques: such as;

a. Stringer beads ---- ( ) always ( ) never ( ) only as required
b. Weave ------------- ( ) " ( ) " ( ) " " "
c. Block ------------- ( ) " ( ) " ( ) " " "
d. Other ------------- ( ) always ( ) never ( ) only as required
(comments)

40. Does your company use special persons to write welding procedures? Yes ___ no ___ If yes, please check:

a. ( ) Welding supervisor
b. ( ) Technician
c. ( ) Engineer
d. ( ) Welding engineer
e. ( ) Consultant firm
f. ( ) Other ___

FUTURE WELDING TRENDS:

DIRECTIONS:
(Evaluate the following statements as to the influence future welding trends will have on industry and welding training.)

41. Do you expect the use of the following weld processes to increase, decrease or stay the same in the next decade?

Weld process	Increase	Decrease	Same
a. Oxyacetylene	( )	( )	( )
b. Metallic arc	( )	( )	( )
c. Gas metal arc (solid core)	( )	( )	( )
d. Gas metal arc(dual shield)	( )	( )	( )
e. Gas metal " (inner shield)	( )	( )	( )
f. Tungsten inert-gas arc	( )	( )	( )
g. Submerged arc	( )	( )	( )
h. Plasma arc	( )	( )	( )
i. Ultra sonic	( )	( )	( )
j. Oxy-fuel gas	( )	( )	( )
K. Other	( )	( )	( )

42. Should welding schools be involved with teaching the following items:

a. Welder certification ------------------------------ ( ) yes ( ) no
b. Teaching of code requirements --------------------- ( ) yes ( ) no
c. Fabrication methods ------------------------------- ( ) yes ( ) no

43. Should welding schools enter into more cooperative educational programs with industry employing welders? ( ) yes ( ) no
If yes, please list suggestions for emplementing. ___

44. Do you have computerized cutting equipment? ( ) yes ( ) no

45. Do you have any welding robots in your shop? ( ) yes ( ) no
If yes, please list details. ___

WELDER AND/OR FITTER RELATED SKILLS AND FUNCTIONS:

36. Equipment operation:

a. Press brake ----------	N	D	U	i. Jigs - fixtures --------	N	D	U
b. Punch ----------------	N	D	U	j. Hydraulic lifts or	N	D	U
c. Band saw -------------	N	D	U	fork trucks -----------	N	D	U
d. Grinders and sanders -	N	D	U	k. Pneumatic tools -------	N	D	U
e. Squaring shears ------	N	D	U	l. Taps, dies, and reamers	N	D	U
f. Nibbler --------------	N	D	U	m. Rigging hoist or			
g. Efficient use of small				jib boom --------------	N	D	U
hand tools -----------	N	D	U	n. Bridge crane ----------	N	D	U
h. Lathe, shaper, mill,				o. Other -----------------	N	D	U
and other machining				p. Other -----------------	N	D	U
tools ---------------	N	D	U	----------------------			

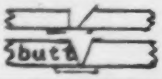
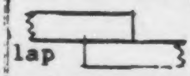
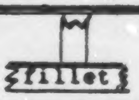
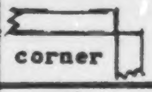
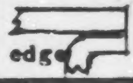
37. Welding related functions:

a. Oxy-acetylene gouging	N	D	U	h. Position for job ------	N	D	U
b. Arc gouging ----------	N	D	U	i. Perform layout operation	N	D	U
c. Metal spraying and				j. Fit up for job --------	N	D	U
finishes -------------	N	D	U	k. Machine cutting -------	N	D	U
d. Perform hardfacing ---	N	D	U	l. Repair welding machines	N	D	U
e. Heat treating of				m. Repair welding machine			
metals ---------------	N	D	U	leads and grounds -----	N	D	U
f. Select materials for				n. Programable welding			
job ------------------	N	D	U	burning equipment -----	N	D	U
g. Select electrodes for				o. Other -----------------	N	D	U
job ------------------	N	D	U	----------------------	N	D	U

MANIPULATIVE SKILLS FOR A PRODUCTION WELDER AND/OR FITTER:

38. In columns below each type of weld joint, select the positions you use the weld process.

SMAW - Shielded metal arc welding
GTAW - Gas tungsten arc welding
GMAW - Gas metal arc welding
FCAW - Flux core arc welding
SAW - Submerged arc welding

Weld joint types	 butt					 lap					 fillet					 corner					 edge				
Welding process	SMAW	GTAW	GMAW	FCAW	SAW	SMAW	GTAW	GMAW	FCAW	SAW	SMAW	GTAW	GMAW	FCAW	SAW	SMAW	GTAW	GMAW	FCAW	SAW	SMAW	GTAW	GMAW	FCAW	SAW
Flat																									
Hor-																									
Vert-																									
O/H																									
*N/A																									

*(not applicable)

WELDING EDUCATION RESEARCH (1964-1984)

This post master's degree research is being conducted for the purpose of providing current empirical data from which welding curriculums may be revised to reflect the changes caused by the upheaval in our economic system.

This analysis has been made to determine how these changes affect the employer, the welder, the welding instructor and the welding curriculum.

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2. To establish the relevance of an occupational ladder.
3. To seek the common factors among the many facets of welding in the various metal fabrication industries.
4. Survey future anticipated trends of welding in industry as to metals, processes and types of applications.

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WELDING EDUCATION REVIEW (1964 - 1984)

by

Charles Frederick Bacon

An abstract of a post master's study
conducted for the purpose of updating
welding technology curriculum

In cooperation with
Everett Community college

1984

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During the time period of the late 1970's and the early 1980's economic upheavals largely unseen since the beginning of the industrial revolution have occurred, directly or indirectly affecting every human being.

The increased inability of American Industry to compete in the world market has forced disastrous changes within the industrial community. We see automated factories utilizing many innovations requiring a work force with entirely different training.

To meet this challenge it behooves the vocational education community to re-examine the precepts lest we train students for nonexisting jobs.

The second stage of the study involved a detailed questionnaire consisting of forty-five (45) questions divided into six different sections:

1. General information.
2. Basic education requirements.
3. Welding related knowledge requirements.
4. Welder and/or fitter related skills and functions.
5. Manipulative skills of a production welder and/or fitter.
6. Future welding trends.

This questionnaire was sent to all Washington and Oregon industries willing to cooperate in an in-depth study.

To provide a comparative base for evaluation this same questionnaire was sent to all regional presidents of the American Welding Society Chapters throughout the United States who represent the many various aspects of industry employing welders.

In Chapter two a computer search was conducted by the University of Washington Libraries computer based "ERIC" database reference service. The areas of concern searched included:

1. Welders' skills and competencies.
2. Metal fabrication skills.
3. Welding instructor qualifications - academic and vocational skills.

This research produced a packet of eighty (80) items ranging broadly with the many related topic descriptors. The data profile produced little that related directly toward the goals of this study.

Based upon the "ERIC" computer search and other professional magazines, I know of no other research paralleling this study.

In Chapter three a summary of the preliminary questionnaire has been provided. There were eighty questionnaires returned with sixty-two or 77.5% indicating their desire to cooperate further in an in-depth study. There were forty-eight or 77% of the respondents who hire welder-fitters for their employment needs. Of the respondents answering, thirty-eight or 61% do not hire any welders directly from vocational training programs. In question five "Would you hire welder-fitters if they were available from local welding schools." Of those responding to this question thirty-four or 55% would hire persons with this training.

There were forty-four or 71% who felt that entrance welders could have been more adequately trained for their welding needs.

The occupational ladder developed from data supplied by the "1974 Welding Task Analysis" study was re-examined to determine its accuracy in 1984. The industrial concerns indicated large percentages do hire helpers, welder journeyman and the welder (specialist or supervisor) while the limited tacker and the welder (instructor and engineer) were hired by only 24% regional and 21% of the national industries.

Chapter four has provided an analysis of the data provided by the regional industries within Washington and Oregon.

Chapter five has provided an analysis of the data supplied from the questionnaires returned by the nationally selected group.

In Chapter six a comparative analysis has been provided concerning current data from this study with data supplied by Bacon's 1964 master's thesis on the welders educational needs and his "1974 Welding Task Analysis."

Chapter seven has provided a summary of the analytical study together with the conclusions and recommendations.

Conclusions

1. The occupational ladder presented in 1974 and rechecked in 1984 has been accepted in part. The helper, welder journeyman, and the welder (special or supervisor) have been accepted by the majority of the regional industrial respondents. The limited tacker and the welder (instructor or engineer) were each accepted by a minority of the respondents.

2. Welder-fitters were accepted and hired by the majority of industry within Washington and Oregon.
3. The majority of the surveyed industrial concerns indicated their willingness to hire welder-fitters should they be trained by the vocational welding schools.
4. Entrance level welders are not hired directly from vocational training schools by a large percentage of the industry employing welders.
5. Entry level welder training was considered adequate by nearly as many industrial respondents as those who considered it inadequate for their industrial needs.
6. Certification requirement to some standard was required by the majority of industry hiring welders.
7. The majority of welders have a union affiliation.
8. A physical examination was required by slightly more than half of the industrial respondents.
9. Advertisements in local papers was considered the best method for the recruiting of welders.
10. Of those having general grade level requirements the high school was required by fifty percent within the region (only). Throughout the nation a large percentage of industry have no basic requirements on education.
11. Throughout the nation welders were principally trained by vocational schools.

12. The welders' basic education involving the scientific laws related to mechanics, mathematics, inter-personal skills related to the supervisory personnel and peer workers was considered desirable knowledge for all welders.
13. The welders' ability to communicate by receiving verbal communications, to verbally direct others, use written planning or procedure specification sheets was considered essential for the welder, but their ability to write reports was not considered necessary.
14. The welders' understanding of economics as related to employment, income and taxes, industrial organizations and family finance management was considered unnecessary.
15. The welder should be able to interpret and use welding related drawings and symbols but not the hydraulic or electrical.
16. Welders are required to be able to fit up parts for welding.
17. Welders are required to understand the metallurgical and welding characteristics of the common metals most used in construction and manufacturing.
18. An understanding of the heat treatment of metals involving annealing, normalizing, hardening and tempering was not considered necessary for the welder.
19. The welders' understanding of electricity as related to the AC-DC rectifier, motor-generator or the alternating current power source was considered desirable.

20. The welders' understanding of the metallurgical properties of metals when welded, design for welded structure, distortion control, affect of welding on heat treated metal and the testing and inspection processes was considered desirable knowledge for the welder.

21. The welders' understanding of the basic type joints and their characteristics when welded, welding terminology, methods of inspection or quality assurance and the awareness to hazardous fumes and gases was considered necessary.

22. Welding related cost factors, estimating costs, cutting of metals with respect to the various cutting processes and their limitations, codes and specifications was considered desirable knowledge for the welder.

23. Welders and/or fitters were expected to have skills in the operation of grinders and sanders, efficient use of small hand tools, jigs and fixtures, pneumatic tools, the rigging hoist or jib boom, the bridge crane (regional only) and hydraulic lift or fork trucks (regional only).

24. The skills welders were not expected to have include the use of taps, dies and reamers, hydraulic lift or fork truck (national only), lathe, shaper, mill and other machining tools, press brake, punch, band saw, squaring shears and the nibbler.

25. The welder should be able to shape metals using the oxyacetylene and arc gouging methods, select electrodes for the job, position for job, perform layout operations, and fit up for the job.

26. The skills welders were not expected to have include metal spraying and finishes, perform hard facing, heat treating of metals, select materials for the job, machine cutting, repair welding machines and the programming of welding burning equipment. The repairing of welding machine leads and grounds was considered a desirable skill for the welder.

27. Welders are restricted as to the welding technique used only as prescribed on engineering drawings.

28. Industry uses special persons to write out welding procedures.

29. The welding processes most likely to increase in usage included the gas metal arc (solid core), gas metal arc (dual and inner shield), gas tungsten arc, submerged arc and plasma arc.

30. Those welding processes thought to decline included oxy-acetylene, ultrasonic, oxy-fuel gas and metallic arc.

31. Welding schools should be involved in the teaching of welder certification, code requirements and fabrication methods.

32. Welding schools should be entering into more cooperative educational programs with industry.

33. The majority of the industrial concerns surveyed do not have computerized cutting or welding robots in their shops, but many are thinking and/or planning for them.

The appendices have been provided to assist the reader with specific and general comments, tables from the preliminary questionnaires, regional questionnaires and the national control group questionnaires.

Appendix A provides all comments received on preliminary questionnaires and preliminary questionnaire data tabulation. Appendix B with parts I through X has provided all comments and data tabulation relevant to the regional and national welders questionnaires. Appendix C lists all regional industrial concerns while Appendix D provides a listing of the control group national industrial concerns. Appendix E and Appendix F lists all the types of products manufactured by the industrial concerns represented. Appendix G lists the preliminary questionnaire, the control group cover letters and information seeking letter. Appendix H has included the in-depth questionnaire mailed to the regional and national industrial concerns.

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